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*"Knowledge is proud that he has learn'd so much; Wisdom is humble that he knows no more."**

ERNST WEBER
FELLOW AIEE

THE HEAVY ATMOSPHERE of the present scientific, technological, and political competition for international leadership demands a dedication to clear objectives coincident with the highest ideals of our unique democracy. We might enunciate such objectives in a general way by stating that we must educate our youth for a full life in conformity with each one's ability to contribute and to enjoy.

But what does this mean, what is the obligation of an Institute like ours, of our faculty, what are the contributions we can make for the benefit of students and of society? We will have to delve somewhat into philosophical arguments but yet remain in the realm of the practical and achievable if we want to give meaningful answers to these questions.

We are a college of science and engineering with a large graduate school and a commensurate research program. In the 104 years of our existence we naturally have undergone many changes in our educational programs. A recent nation-wide re-evaluation of engineering education has pointed to the need of strengthening the scientific foundation of engineering programs and in the course of many deliberations—and some of these have been exhaustive in every sense of the word—several new concepts arose. Although my remarks will be specifically aimed at our own situation at Polytechnic, they are significant for the national scene with appropriate local modifications.

HERITAGE

TRADITIONALLY, engineering represents the purposeful application of natural phenomena. The primitive beginnings of engineering made use of the empirically found qualitative properties of materials in building the homes and temples of the ancient peoples. Early observations on the flow of water were used in designing the irrigation systems and in building water supply systems. Simple mechanical laws were employed in constructing the military tools during the aggressive and expansionist periods of the Greeks and the Romans. Today, many would like to add to the simple definition of engineering just given a peaceful objective by saying that it represents the purposeful application of natural phenomena "for the benefit of mankind." Yet, we cannot escape the military applications and much discussion has recently centered on the social implications of this fact. I shall return to this point a little later.

The distinct objective of science is the accumulation of verifiable knowledge. In ancient times, simple observation and logical deduction were the only sources of new knowledge. Verification in the sense as we are accustomed to accept it was hardly considered. Although the contributions to mathematics, geometry, and even hydrostatics were quite remarkable, engineering received little new knowledge for which to find purposeful applications.

Let us skip the long gap in science during the Middle Ages and rush to the most significant invention of all times: the printing of books around 1450. Probably nothing has contributed as much to the explosive development of modern science, to the systematic exploration of the earth, and to modern civilization as has the printer's press, the medium of mass communication. Setting our reference point near the year 1500, scientific discoveries in the field of natural phenomena have

> Search for knowledge is the systematic inquiry into man's environment as well as into man himself. Mere intelligence and knowledge, per se, are both amoral. What counts is what is done with intelligence, with knowledge!

Essentially full text of an address delivered on the occasion of Inaugural ceremonies installing Dr. Weber as the Sixth President of Polytechnic Institute of Brooklyn, in Brooklyn, N. Y., April 19, 1958.

*W. Cowper, The Task, VI (1731-1800).

multiplied exponentially right into the present-day period; or, in other words, the number of new discoveries in any one decade remains proportional to the sum total of all discoveries of all decades, a formidable rate of increase, indeed. Based on the scientific discoveries, engineering developments during the 17th and 18th Centuries ushered in the great industrial revolution. We might well call in succession the 19th Century, the century of steam; the 20th Century that of electricity; and we can look forward to the 21st Century as the age of nuclear energy.

THE NEED

To cope with the established rate of scientific progress, engineering education today must reorient itself. No longer can the engineer just be equipped with skills, as it appeared desirable even 25 years ago. Today, we must educate scientific engineers, well founded in the fundamental laws of science and able to keep pace with new scientific developments. We must set our sights at 20 years ahead, when today's graduating engineer will be in his prime professionally, and should be able to utilize the whole spectrum of new knowledge furnished by scientific research.

You will ask: Is this humanly possible? Perhaps I should give one rather obvious answer. We ourselves, as teachers, must continuously keep abreast, we cannot possibly fall behind lest we risk being reduced to menial assistants of those who can keep pace! And it is possible to keep pace if one has genuine understanding of the relatively few generic principles on which most other scientific laws and relations are based. We must therefore, avoid having students look at the trees rather than at the forest. We must present the modern ideas in their own setting, not as end points of belabored prerequisites which often are just peculiar sequences of accidental developments. This requires, of course, excellent teachers, themselves steeped in the basic sciences. It also requires a core of teachers actively engaged in some phases of basic research to keep alive the professional growth of the entire staff.

But even with outstanding undergraduate teaching, it is not possible today to prepare students adequately for advanced engineering research and development activities. More and more, the emphasis increases upon additional graduate study and research. Unfortunately, within recent years, the shortage of scientific and engineering manpower has led to competition by industry for the young graduate so that few of the most capable ones stay on to enter graduate schools. The seriousness of this situation has been pointed out by committees of the American Society for Engineering Education (ASEE) and has led to the recently proposed enlarged national fellowship program which is now before Congress.

Unless we can attract larger numbers of the outstanding engineering students into graduate schools, we shall not be able to supply the requisite number of scientific engineers of high caliber who will be our team leaders of tomorrow. Unless we can secure adequate outside support for our basic research programs either from Government or from industry, or both, we shall not be able to maintain the high level of graduate teaching and of research which is so indispensable to faculties in graduate schools.

But, to prepare the team leaders properly for their social functions and responsibilities, we must provide more than programs of scientific engineering which give knowledge; we must include effective contact with those subjects which will eventually lead to wisdom. We realize that we cannot train for a full life, we must recognize that we can only give opportunities for it, but we need to stimulate the desire to broaden the outlook by creating the appropriate atmosphere.

CHARGE AND COUNTERCHARGE

It has been charged that preoccupation with science and engineering leads to materialism and, hence, to *asocial* if not antisocial behavior patterns. When recent demands were made to increase the volume as well as the level of science teaching in elementary and secondary schools, many voices of criticism were raised that we might lead our youth into the extended arms of materialistic philosophy. Let us not forget that mere intelligence has no morals, intelligence per se is neither moral nor immoral, it is amoral. Knowledge per se, as an index of intelligence, is likewise amoral. What counts is what we do with intelligence, with knowledge! This is exactly where the right environment, the proper stimulation of the social aspects of mankind play the important role to bend knowledge into wisdom, to make intelligence a constructive element for the greater benefit of mankind.

Although it is undoubtedly true that as a nation we already crave too much for material possessions as a measure of so-called happiness and success, preoccupation with the study of science and engineering is not the cause of it, and should not be blamed for it. Where else could we find so much evidence of our basic ignorance if not in the search for knowledge and its applications? Where else do we find such overwhelming evidence of the natural laws imposed beyond our control, but inexorably active whether we observe or not?

Search for knowledge means the systematic inquiry into our environment as well as into ourselves. Newton's discovery of the law of gravitation as such could have been made generations, nay, millenniums before, if mankind had been ready for it. All the elements of the simple observation of a falling apple had been there since uncounted ages, and perhaps someone at some time had formulated the law of gravitation—but had not committed it to something that we could find in archeological expeditions. It is a most startling discovery for the nonphilosophical mind that mankind on earth is in the process of mental evolution which makes someone ready, somewhere, at some specific time to see a new relation, to discover a new experimental fact, to stumble upon a new process. This is so well expressed in the book "History of Galvanism" (Histoire du Galvanisme) by Pierre Sue in 1802, that I quote:

"In all sciences there are many truths for the reception of which it is absolutely necessary that men's minds, *even those of the higher order*, be suitably prepared. If these truths are discovered before this time, they will be contented, smothered at birth and forgotten. They appear as flashes of light, piercing the gloom of a cavern, illuminating it for one brief moment, only to abandon it once more to the darkness of night."

METHOD OF ATTAINMENT

IF WE WOULD ONLY PAY MORE attention to the history of science and engineering, we would be deeply impressed with this aspect of a maturing process of mankind, much the same as we observe in each individual. We would most certainly then find it interesting to study also the development of art, of literature and philosophy, and as their social expressions of the forms of economic thoughts, of the systems of government—in short, the whole gamut of the broad spectrum of humanities. But we would not concentrate as so many college courses now demand, on dates and data, on names and first names, on battles and heroes, etc. Rather, we would study the flow of continuous evolutionary development, from a distant point of view as far as the past is concerned, from a personally involved point of view when we get to the present.

Teaching of humanities to engineers from such an integrated point of view would bring to the subject the broad philosophical point of view so essential in promoting the germination of wisdom. It would also have the great advantage of crystallizing concepts and ideas around the professional area of interest. Of course, to initiate a program of this type requires teachers that are not readily available; it requires devoted men who themselves have come to this approach as a personal human experience and who value wisdom as an asset in establishing attitudes toward human situations. Perhaps we can take, as a symbolic step in this direction on our own campus, the two "Plexiglas" panels installed in the entrance hall and depicting an artist's conception of science and engineering, respectively.

Studying the evolution of the scientific method of inquiry and, flowing from it, the unfolding of the engineering utilization of the discoveries, we must be impressed with the tremendous range of unpredictable new possibilities. The opportunities for new discoveries always exist, but we can cultivate them by providing a genuine research atmosphere. Logical as science appears and likes to appear, its development is rarely by systematic plan and unerring progress. Unfortunately this has not been recognized in most of the national programs for sponsorship of research or giving of research grants. A well-intentioned but pernicious system requires the submission of a completely detailed outline of what the scientist will do, what he intends to find, and how he will go about finding it. I submit that this is just stimulating mediocre research where you dare not go far and above all dare not think too originally! True scientific research cannot be planned in all its details and requires, first and foremost, the maturity of the person engaged in it to see and to recognize the new. To support it, grants should be made available to qualified people without restrictive covenants and specific terminal dates for an accomplishment.

POPULAR FALLACY

YET, the general popular impression has been created that scientists and engineers are different kinds of people, are people who know at every instant exactly what they want to do and what the result of their labors will be. Perhaps some scientists have helped in creating the myth of almost superhuman gifts and talents; or perhaps it is just that the public has subconsciously wanted to remain uninstructed in scientific matters.

But, I have asked this question before: In this age of science and engineering, why should the complete lack of science subjects in the education of our young people be any less "lack of culture" than engineering without humanities?

And, I contend: The perception, through observation of simple laboratory experiments, that we live in a world of physical law and order, impressed by causes beyond our control, is first-hand knowledge that should not be barred from any child!

The recognition that these physical and chemical laws operate inexorably and have always been operative, whether we could formulate them or not, is a most important ingredient of human knowledge.

The schism between science and nonscience is the more deplorable because it has been carried into accusations that the scientist should be responsible for the social consequences of his discoveries and, yet, it is the nonscientist who makes the decisions of exploiting these discoveries for peaceful or military purposes. In a recent article, C. Frankel,* professor of philosophy at Columbia University, New York, N. Y., says this:

> "Those who take fixed positions in such a world (as this present revolution is creating), and who deny the usefulness of scientific knowledge in resolving moral and political dilemmas, will be pleading merely for the rule of dogma or of their own private intuitions. It is unreasonable and unattractive to think, that the society of the future should be ruled by a scientific elite, masquerading as moral experts. It is equally unattractive to think that it should be ruled by those who make a principle of ignorance, and whose claim to be moral experts rests on their sense of superiority to the processes of sober scientific inquiry."

We need to aspire to a grand synthesis of all the spectral components of man's potential in order to provide the full life man is capable of. We must graft into the educational program of the scientist and the engi-

*"Third Great Revolution of Mankind," magazine section of the *New York Times*, Feb. 9, 1958, p. 11, etc., particularly p. 17.

neer a significant and meaningful exposure to the story of evolution of thought, and expand it into the realms of philosophy, of literature and art, and of economics and government. But we must also inject into the liberal arts curriculum a significant and meaningful exposure to scientific methods, perhaps most suitably in terms of history of science amplified by *real* study in a particular sector. It is as important for the scientist and engineer to recognize other modes of contribution and enjoyment, as it is important for the nonscientist to realize the exacting rigor of the search for truth.

KNOWLEDGE AND WISDOM

AND, AS I SAY TRUTH, the full impact of the title of this address comes again to mind: Knowledge is proud—wisdom is humble! The searcher, since every step deepens his insight into the field that he has chosen, will easily generate a feeling first of pride, then of superiority, and eventually of impatience with those who cannot or will not grasp his teachings and are apt to argue. Yet—what is he searching for? How can he be sure it is truth; and, if it is accepted as truth today, will it be so accepted tomorrow, next year, or in 100 years? Can truth, in this sense, ever be absolute? Man has the distinction of being able to reflect upon himself, to search himself out, and to ask most embarrassing questions as to why and wherefore. Are these questions in the realm of science or are they in the realm of philosophy or of religion? Must science recognize its limitations, at least as temporal, because of this evolutionary maturing which implies a tremendous world of new phenomena and new relations ahead that we are not yet able to see, nor even to ask questions about? We need only go back 150 years to erase all knowledge of electromagnetism and with it the civilization that we define as standard of living today. Yes, "wisdom is humble that he knows no more!"

Perhaps the most imposing dramatization of science and philosophy as related to man's struggle for absolute knowledge is the story of Faust. To put it in the proper perspective, permit me again to go far back in history. The philosophers of the early middle ages and even up to about 1500, just before the time of Leonardo da Vinci and Copernicus, had argued long and elaborately from the scriptures and from dialetic principles about the meaning of life and the purpose and destiny of man. But the spoken and written word was taken as the essence, no search for facts was conducted, science as we would define it did not exist. True, Roger Bacon around 1250 had called for a new science, that of experimentation, but very little true experimentation was done, most was left to alchemy and magic which flourished all over Europe, having come originally from the Near East. In fact, all magicians were considered as agents of the "Evil One," which effectively mitigated against scientific inquiry and caused so much of the early martyrdom among courageous scientists.

KNOWLEDGE VS WISDOM

ONE OF THE MOST LEGENDARY figures of the times between 1500 and 1560 seems to have been a Doctor Johannes Faust who had acquired considerable knowledge and performed black magic as a traveling scholar all through Italy and Germany. Perhaps because of his travels and unexpected appearances, perhaps because of the awakening of critical attitudes, many legends sprang up and probably several different characters were merged into one having the explicit pact with the devil as the central theme. It is most interesting to realize that this happened at the time of Leonardo da Vinci, whom we could call the first scientist–engineer, of Copernicus who argued the heliocentric system, of Vesalius, the first significant contributor to anatomy, and of Martin Luther who ushered in the Reformation. The traveling scholar of that time had, indeed, much to convey from place to place that sounded incredible and exciting. Legend also had it that Doctor Faust did not die a natural death but was found "lying beside his bed with his face twisted round to his back, thus he had been destroyed of the devil."

The first Faust book was published in German in Frankfurt am Main in 1587 with this interesting title: "History of Dr. Johann Faustus, the far-famed Sorcerer and Master of the Black Art, How he sold himself to the Devil for an appointed time, what strange adventures he saw, himself brought to pass and carried through in the meanwhile, till at length he received his well-earned reward. Compiled and printed largely from his own surviving Writings, an appalling Example, abominable Instance, and well-meant Warning to all presumptuous, curious, and Godless Men."

Apparently this book went like wildfire over Europe being added to and made more dramatic. It was also immediately translated into English where it came to the attention (if not already in the German edition) of Christopher Marlowe who almost at once wrote his famous drama "Tragical History of Dr. Faustus" which was performed in 1588 with great success. After Marlowe's untimely death in 1593, at the age of 29, many other authors appropriated the drama, provided embellishments and it was a fairly common play for at least 170 years.

Thus, the Faust drama must have come to the attention of young Goethe about 1770 either as puppet play or as stage drama. The theme of the struggle for knowledge and in particular for a final satisfying answer appealed so strongly to him that he recreated the character and introduced philosophical discussions in poetic form unsurpassed in the literature. Retaining the central theme of the pact with Mephistopheles, Goethe has Faust specify that his soul will be forsaken

> "When to the moment fleeting past me,
> Tarry! I cry, so fair thou art!
> Then into fetters mayst thou cast me,
> then let come doom, with all my heart!"

It is up to Mephistopheles to provide enjoyments of a full life and to induce Faust to have some phase of it be of lasting satisfaction.

The work about Faust progressed slowly because Goethe injected his own mental evolution. Finally, the

concept of the Faust drama had become so large that he finished Part I in 1808 as a separate drama embodying essentially the tragedy of Margarete which Gounod has set to such unforgettable music. But it is Part II that I would like to refer to particularly. Goethe finished Part II shortly before his death in 1832 and undoubtedly has incorporated into it his own mature philosophy of life. In his insatiable urge to find happiness in worldly entertainment provided by Mephistopheles, Faust passes through all the glamour of the ancient Greek culture. But nowhere does he find any situation that would make him enjoy the moment to wish it to last. Finally as an old man, Faust organizes a team to combat the seas in Holland, to lay dry vast stretches of land for agricultural use by the people who have no land of their own. Contemplating the social benefits of this feat of engineering, he feels compelled to utter the words

". . . liberty, as life, alone deserveth
He daily that must conquer it.

• • •

Fain would I see such glad turmoil
With a free people stand on a free soil.
To such a moment past me fleeing,
Tarry, I'd cry, thou art so fair!
The traces of mine earthly being
Not countless aeons can outwear."

As he falls back dying, Mephistopheles rushes up triumphantly, but he cannot take the soul of Faust—the satisfaction that had compelled Faust to wish for this moment to last had not been due to Mephistopheles, it had been the creative imagination of Faust resulting in engineering application of scientific knowledge for the benefit of mankind!

Philosophy of Engineering Reliability

M. L. MILLER
MEMBER AIEE

Reliability is a complex interplay of design, environment, test equipment, and maintenance skills amongst other influential factors. In this first part of a two-part article, practical field reliability—a result of subjective processes of predictability, assessability, education, and probability evaluation—is discussed in detail.

Part I

THE CLASSICAL IDEA of a perfectly reliable device is the "One-Hoss Shay." This device has such poetic beauty in its design that only recently has it become apparent that there is something fundamentally unsound with expecting only total and simultaneous collapse of all of the parts of a mechanism. Practical work has shown that in spite of the best design efforts, good equipment suffers from individual parts failures more or less at random throughout its useful life rather than total collapse. At one time, this was looked upon as the result of inadequate understanding of reliability, and it was hoped that it would go away when understanding replaced intuition. Alas, it did not. The mathematician has brought the concept of probability into the picture with the result that the understanding has shown how to make the random failures less frequent, but at the same time has made their very existence respectable by showing them to be inevitable.

Field reliability is the result of a complex interplay of the forces of design, environment, test, and human opinions. In this two-part article, it is our intention to cover briefly some of the more important aspects of these problems involving the broad scope of definitions, subjectivity, life testing, instruction books, and equipment design.

The dictionary definition of the word reliable is "trustworthy, dependable, worthy of confidence." Engineering products of considerable complexity have a rather roundabout way of earning this badge of confidence called reliability. Let us look at the process of creating reliability in an engineering product somewhat as shown in Fig. 1.

One look at this process and it becomes apparent that there is considerable opportunity for the possibility of a large discrepancy between the potential reliability and the actual reliability of an engineering product. We are interested in the actual reliability.

The process of creating reliability involves test, inspection, use, and maintenance. We must be prepared to understand and evaluate (at least qualitatively) such things as the manner in which the test equipment fits the product; the effects of environment on the product; the ease of maintenance; the skill and knowledge of the

A special article recommended for publication by the AIEE Research Committee.

M. L. Miller is with the General Electric Company, Fort Wayne, Ind.

operators, inspectors, and maintenance personnel; and the mental process used by these persons in arriving at their opinions of reliability.

Fortunately, there appears to be several concepts that are common to all the parallel paths shown in our process diagram. The first of these is the concept of predictability. This is the process of determining what should happen during test or use. The second is assessability. This is the process of determining what does happen during test or use. The third is the concept of probability and stems from the need to handle predictions numerically. This is the process of determining what is apt to happen in the future.

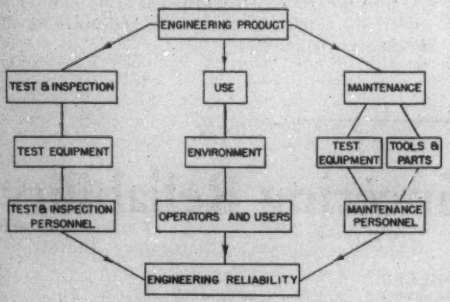

Fig. 1. The process of creating engineering product reliability.

Reliability is almost always a comparative quality in which it is said that one item is more or less reliable than another. When comparing nearly identical devices, the idea of comparative reliability is easy to reach. Your watch is either more or less reliable than mine, and rather simple measurements and definitions will generally suffice to establish this fact. However, when an attempt is made to find out whether your home refrigerator is more or less reliable than my watch, the need for careful definition and basic understanding of the problem becomes very apparent.

As with many similar problems, there appears to be two levels (or parts) to reliability. These are what we will call subjective reliability and measured reliability. Unfortunately, it will be found that it is not always possible to separate these two levels adequately. Subjective reliability is that part of reliability formed in the minds of the interested persons which is unmeasurable. It depends, of course, greatly upon the individual and can range from pure prejudice for the uninformed to almost equally naive opinions based only on the results of tests and measurements. Neither extreme constitutes a true concept of reliability.

Measured reliability constitutes those aspects of reliability that can adequately be encompassed by definitions and specifications in such a manner that successful tests and measurements are actually completed. The application of infinite testing and education would supposedly make it possible to have measured reliability completely encompass subjective reliability. Later it will become apparent that such a result is a near impossibility for any device having either wide usage (because of the difficulty of education), or great complexity (because of the difficulty of test). We will now discuss the major aspects of subjective and measured reliability separately.

SUBJECTIVE RELIABILITY

Introduction. Subjective reliability is a sort of personal reliability. It is greatly dependent upon the background and education of the individual, and its study provides many interesting and useful ideas on how to improve reliability. For a single device, it can be quite different for different persons. Because of this, many engineers and designers pass it off as being "pure prejudice," but frequently it is just as real and important as that part of reliability that can be measured. Let us turn now to its study in terms of some of our basic concepts.

Predictability. Many of those aspects of reliability that provide predictability are dependent upon subjective interpretation. Reliable devices must have a predictable behavior.

Reliable devices should have only the essential input and output requirements specified. Thus, exact predictions concerning the intermediate behavior are not required neither do they need be tested for. Because this aspect also has a counterpart in measured reliability, it will be discussed in more detail later.

Predictability of the whole system and its component parts is an essential part of subjective reliability. Such predictability is achieved most easily by having everything follow simple universally understood physical laws. Horses in races, people in groups, and the weather in general, are all considered unreliable because the laws governing their actions are neither simple nor universally understood. Ohm's law and Newton's law are sufficiently simple and well understood that systems following these laws are generally considered reliable. Maxwell's equations are equally simple but less universally understood, so that microwave systems, which generally depend upon such laws, are frequently considered "unreliable."

Education as a Part of Predictability. It is now apparent how education fits into the problem of subjective reliability. To make accurate predictions of the behavior patterns of engineering devices, it is essential that a knowledge of the basic laws involved be available to the persons making the predictions. This problem of education can be viewed from several aspects. The use of the device can be limited by laws or rules to those having the proper education and training.

Proper education can take the form of a good instruction book for the equipment. Besides the obvious need for making this instruction book available, attractive, and well organized, there is the added need of subjective reliability. It should explain clearly, at the level of the

expected reader, how each portion functions and what laws are involved. It should sometimes provide curves, graphs, or simple analogies to permit the user to make accurate, rapid predictions. The book should clearly state the specifications, limitations, and parameters requiring control and measurement.

Instruction books written in this manner should help to achieve proper education of those persons using the device so that their subjective reliability of the equipment will be improved. For example, the subjective reliability of a vacuum tube is almost certainly improved by supplying the circuit designer (user) with adequate curves of its performance.

Assessability. The aspect of assessability, although primarily a problem in measured reliability, is not without its problems in subjective reliability. These subjective problems are nearly the same as those of predictability. It is necessary to provide proper information to personnel operating and maintaining the unit about what should be measured, with what devices, and what results should be achieved. Proper specifications, tolerances, and test procedures must be available or subjective reliability will suffer.

Assessability requires access to the equipment through the use of properly marked test points, etc. Proper test equipment must be specified or sometimes even furnished with the equipment. Means for calibrating the test equipment should be made available.

Probability. Whenever it is necessary to appraise the future, and this is a fundamental need when working with reliability, subjectivity can easily become an overriding part of the appraisal. Indeed, one is fortunate if enough real evidence and measured facts are at hand to permit any but a subjective handling of the future. Reliability can frequently be reduced to a measurable set of quantities, but the actual measurement may constitute a nearly impossible task with the result that subjective evaluation of the probable reliability is required. To provide measured reliability, the technique of sample testing is generally applied. This method of evaluation leaves much to be desired, but remains the only nonsubjective method known to man. It is interesting to note that two methods of subjective evaluation have achieved considerable acceptance. One of these can be called the "pari-mutuel" method in which the average of a number of financially backed opinions is offered as the probability of success. For example, the engineering staff bet their next pay raise that some new device will work. The second is clairvoyance with which the future is predicted by sheer force of will power or intuition. Pari-mutuel evaluation can result in predicted numbers for reliability but not in measured numbers for reliability. For example, a man can bet $50 that Device *B* is twice as reliable as Device *A* without having performed any tests whatsoever. Thus, it can be seen that numerical reliability is not always the result of measured reliability.

As it will be shown later, the pari-mutuel evaluation of reliability can be skillfully blended with scientific sampling to provide reliability information otherwise unattainable. This tends heavily toward subjective reliability but when backed up by the well-established name of a firm (or sometimes an individual) it may well find wider acceptance than reams of data presenting measurements of reliability. There is an ever-present danger (both to the manufacturer and to his customers) that the manufacturer will be emboldened by this partially subjective reliability. He may then accidentally and suddenly break forth into pure subjective evaluation through clairvoyance and somehow or other become a loser. Losing at this is rather easy after it is forgotten that facts were once the basis for the opinions and no longer seem to be needed.

A complex device, of which only one or two are to be constructed, cannot be claimed to be either reliable or unreliable. However, it can be said from experience that similar devices have proved in the past to be reliable or unreliable and then pari-mutuel (or clairvoyant) appraising of the future can be called upon to estimate the probable reliability for the next mission. This is almost pure subjectivity.

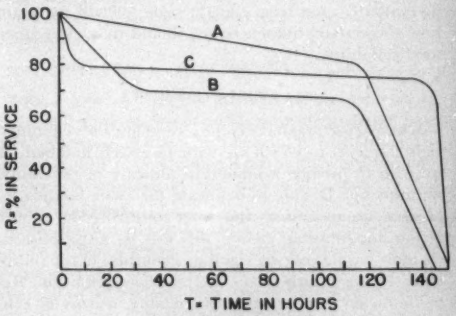

Fig. 2. Reliability curves.

Unnecessary Restrictions. Subjective reliability requires one additional aspect. This is the deletion of all unnecessary intermediate measurements and specifications. To write a specification on every junction point or connection in a device leads to poor subjective reliability by tending to override the inherent safety factors of the design. For example, two screws with 50% thread are sufficient to hold a part in place. The designer uses three for a safety factor. During production, occasionally one hole is improperly tapped. If the specification requires all three screws to have at least 50% thread, an unnecessary requirement is placed on the device. In the eyes of an inspector, the subjective reliability is lowered even when all the devices are completely functional and reliable.

Homogeneous Systems. There seems to be a natural tendency to believe that highly homogeneous systems should be more reliable than heterogeneous systems. This belief is well founded in the idea of predictability. Homogeneous systems follow a single set of laws, thus they are simpler to understand, more predictable and,

therefore, more reliable than complex systems. Since they may also be more easily manufactured, tested, and controlled, improved measured reliability can result from homogeneous systems.

For example, a continuous-flow process compared to a batch process is a kind of time homogeneous system and frequently is considered more reliable than a batch process. The process of mass production is a kind of homogeneous process based upon similarity of products rather than process steps. Subjectively, at least, there seems little doubt that the homogeneity of product resulting in repetitive identical operations results in process reliabilities far greater than could be achieved with heterogeneous products. Could you reliably make mouse traps, bird cages, and electric motors on the same production line?

Summary. The understanding and use of subjective reliability can help to provide ideas for changes in design, advertising, or use of the equipment. However, without the assurance of measured reliability, subjective reliability can seldom stand alone. We turn now to measured reliability to study its aspects and how it can be evaluated, but from time to time we will see again how subjectivity influences (or should influence) measured reliability.

MEASURED RELIABILITY

MEASURED RELIABILITY is the second level of reliability. It is the level to which we wish to attach numbers. If we wish to provide a numerical measure of reliability, we must first be able to delineate the exact boundaries of what we are testing and what constitutes its proper action and mission. Before this can be accomplished, we must have a concise, rigorous definition of reliability itself. Let us return to the introductory definition. Reliable means "trustworthy, dependable, worthy of confidence."

First Definition. A more reliable device is one that is more apt to complete its assigned mission without failure. The National Symposium on Reliability and Quality Control has effectively adopted the definition:

> "Reliability is the probability that a system will give satisfactory performance for a given period of time when used in the manner and for the purpose intended."

This can be stated in greater detail as follows: Device *A* is more reliable than Device *B*, for the stated interval if at the beginning of the interval, *A* has a higher probability than *B* of operating throughout the interval in a satisfactory manner. For "one-shot" devices (such as matches, fuses, and ammunition), the word and idea of event must be substituted for interval.

For most purposes, this definition will suffice and it is of such a nature that its numerical evaluation can be readily obtained by simple statistical methods. However, before these simple statistical methods can be applied to provide such measured reliability, the question of what is the "stated interval" and what is "operating throughout" and what is a "satisfactory manner" must be answered.

The "stated interval" generally should be the interval of intended use, or at least nearly the same interval.

"Operating throughout" is an important aspect of operation that must be firmly established but customary engineering methods will suffice. A 2-minute failure of an automobile engine in a 1,500 mile trip might be acceptable whereas for an aircraft engine it would probably be classed as failure.

"Satisfactory manner" should be based upon the best pragmatic interpretation of the intended use or uses of the device under test. Once these necessary pragmatic interpretations of the requirements are established, then the technique of scientific sampling and testing can generally be applied. From this, a knowledge of the statistical behavior of the family from which the samples were drawn can be obtained.

After this knowledge of the statistical behavior of a family of devices is at hand, a plot of the per cent in service vs time can be prepared; such as the curves presented in Fig. 2. A curve such as this becomes a graphical presentation of the data required of the definition (within the limitations of the specifications and test procedures used) and will give exact numerical values for the probability of completing any mission equal to or shorter than the interval of the plot.

For a one-shot device, since no time interval is involved, the whole curve degenerates to a single numerical value of probability of success.

Because of the nature of well-designed complex equipment, reliability curves frequently resemble exponentials. The exponential reliability curve is characterized by a constant (random) failure rate which can be expressed as a single numerical value. This failure rate, therefore, can sometimes be substituted for a measure of reliability. Such a simplification is not in strict keeping with the definition, and is completely justified only when the failure rate is constant. It is quite useful for many purposes. For example, if the intended use covers a very brief interval of the expected life of the equipment, then failure rate becomes an excellent measure of reliability.

Let us turn now to a few simplified illustrations of the reliability curve and its uses. The curves here presented are far from being practical ones. They have been drawn with shapes especially fitted for simple illustration. Fig. 2 is such a family of plots which could be useful in comparing three devices—*A*, *B*, and *C*. From Fig. 2, Device *A* has 90% probability of completing 60 hours of operation and about 45% probability of completing 130 hours of operation. Device *C* has 80% probability of completing 15 hours. It can then be said that Device *A* is 90% reliable at 60 hours, 45% reliable at 130 hours, and that *C* is 80% reliable at 15 hours. Since Device *B* is 70% reliable at 30 hours and 65% reliable at 110 hours, it can be seen that 30 hour *B* survivors will have about 93% reliability for an 80-hour mission.

Curves such as these can be prepared for different devices operating over equal or unequal intervals and

tested against identical or widely divergent specifications or test procedures. If the devices are similar so that identical or nearly identical specifications are used, then there is almost no subjectivity in the results of the measurements. As it becomes necessary or desirable to alter the specifications, the numerical values may take on some subjectivity along with the measured reliability. For example, if one family of devices is tested at twice the load as a second family (other things being equal) and these tests show nearly identical numerical reliabilities, it can be stated that the first is capable of twice the load of the second with almost no subjectivity. However, when we try to test your home refrigerator and my watch for comparative reliability, our test procedures and specifications may contain considerable subjectivity and, thus, our results may contain subjective reliability even if it appears to be measured reliability. To all of those who completely agree with our test procedures, we have achieved a measured comparative reliability between a watch and a refrigerator; others may consider it somewhat subjective.

For systems or devices subject to readjustment or repair, additional information may be required to assess the reliability properly. In a repairable system, the usefulness of a device is sometimes proportional to the service hours rather than the length of life, and this can be reflected into the concept of reliability. On other occasions, the cost of maintenance has become a part of proposed reliability definitions. As yet, there seems to be no well-accepted standard definition of engineering reliability for equipment subject to maintenance. For lack of a better definition, it is proposed here to use the integrated expected life of the equipment as the basis of a second definition. The area under the curves *A*, *B*, and *C* of Fig. 2 is shown as Fig. 3.

Second Definition. A device that is either more apt to complete its mission without failure or is expected to render (under maintenance) more hours of satisfactory service, is more reliable. If plots of per cent in service vs time are prepared along with plots of the area under these curves for each device, they may be compared. Such curves are presented in Figs. 2 and 3. If the equipment can and will be maintained, the integral curves should prevail, otherwise the per cent in service curves. In general, the integral curves cannot be used to compare dissimilar devices unless the problem of maintenance of the compared devices can be shown to be nearly identical in cost, time, etc. If the dissimilarity is large, the evaluation should be reduced to a cost of maintenance problem and not considered a part of reliability.

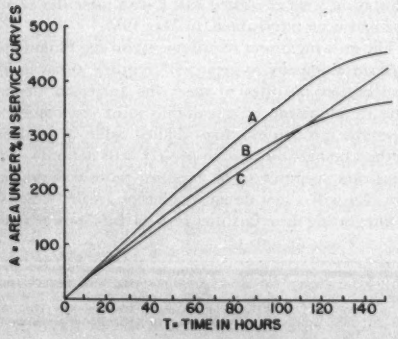

Fig. 3. Area under the curves of Fig. 2.

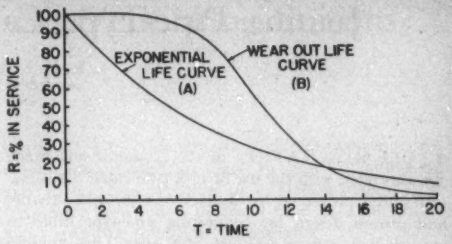

Fig. 4. Practical reliability curves.

PRACTICAL SHAPE OF LIFE CURVES

LIFE CURVES of complex mechanisms can take on an unlimited number of shapes. Many of these shapes have been described mathematically and justified by logic. Only two will be mentioned because they are the ones most easily understood and they will suffice for our limited purposes.

The simplest life curve is the exponential life curve shown in Fig. 4 curve *A*. It is characterized by having a constant failure rate. The failures are generally assumed to be random. This type of life curve can result from the accumulation of the large number of incidental causes distributed throughout the equipment. It is this type of failure that occurs after all known and controllable sources of failure have been designed out of the equipment.

A second shaped life curve is the result of wear-out. One such curve is shown in Fig. 4 curve *B*. In this case, one can expect the failures to be bunched into a group centered about some average life. Only a few devices will show life greatly different from the average. This type of failure occurs as the result of such things as metal fatigue or the exhaustion of some built-in supply of material such as bearing metal, lubrication, cathode emissive material, etc.

Many shapes can be derived by simple combinations of the aforementioned two. Practical life-test data frequently show shapes quite similar to these basic shapes or simple combinations of them.

The second half of this article will expand upon the uses of the present definitions and concepts, and attempt to show how the reliability of parts influence the system reliability. It will also discuss briefly the importance of life testing, and provide some comments on system design.

Joining Pipe-Type Cable to Oil-Filled Cable

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FULL REALIZATION of the economic advantage associated with the use of pipe-type cable has sometimes been prevented by the lack of a joint of suitable and proved design for connecting pipe-type cable to existing low-pressure oil-filled cable lines. This problem arose anew in connection with the design of supply lines to Lombard Substation, Philadelphia (Pa.) Electric Company's newest 66/13.2-kv substation. Here the advantages of using pipe-type cable in conjunction with an existing oil-filled cable were sufficient to justify considerable effort to develop a practical method for connecting these cables. Co-ordination with high-voltage cable and accessory manufacturers resulted in the production of satisfactory stop joints, six of which are in service on the new project.

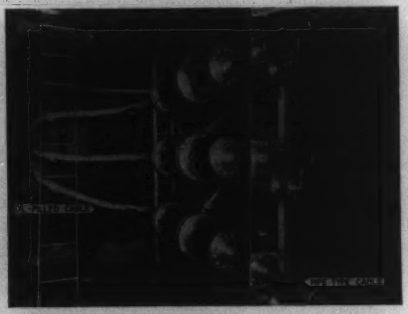

Fig. 1. Completed installation of 69-kv stop joint for connecting pipe-type cable to oil-filled cable.

The new substation, located in central Philadelphia, is supplied by two new 69-kv, 100-mva cable lines. One is a direct pipe-type cable line from Schuylkill Generating Station, and the other is formed by a new loop of an existing line between Schuylkill and Southwark Generating Stations. The existing line is an oil-filled cable line, but pipe-type cable was chosen for looping it through Lombard Substation because of the savings that could be realized with this type of construction at this location.

The oil-filled cable line was installed on the Philadelphia Electric system in 1946 and consists of three 69-kv, 1,500 MCM (thousand circular mils) copper conductor, paper insulated, lead sheathed cables in concrete jacketed fiber ducts. The pipe-type cable is composed of three 69-kv, 1,500 MCM copper conductors with paper insulation installed in 6⅝ inch outside diameter (OD) somastic coated steel pipe.

The joint that was developed to connect these two types of cable consists essentially of two porcelain cable heads mounted horizontally, connected with flexible copper straps and enclosed in an oil filled, nonmagnetic stainless steel casing. The casing is 14 inches in diameter and is composed of three sections. The end sections are connected to the base of the porcelain cable heads and are sealed to the center sleeve with Dresser couplings. The assembled joint is approximately 8½ feet long. Fig. 1 shows the completed installation of the joints in the manhole.

The new stop joint contains three oil systems. The high-pressure oil of the pipe-type cable system and the low-pressure oil of the oil-filled cable system are contained inside the porcelain cable heads that terminate their respective cables. The area outside the porcelains and inside the steel casing is filled with approximately 30 gallons of cable oil and constitutes the third oil system. This oil is maintained at 5 to 12 pounds per square inch (psi) by separate 4-gallon, type a-c reservoirs located in the stop joint manholes. An alarm circuit to a nearby attended substation monitors the casing oil pressure of the joints.

Prior to the installation of the new joints on this system, one joint was completely assembled and tested in the supplier's high-voltage laboratory. The joint successfully withstood the tests at the 69-kv level of AIEE No. 48—Standard for Potheads. Successively higher voltages were then applied for 6-hour periods until the pipe-type cable failed outside the joint after 26 minutes at 172 kv. Dissection of the joint did not reveal any damage to or deterioration of its components.

The task of installing these complex new joints with a minimum outage to the existing cable line was a large one. The work proceeded around the clock without incident, however, and the new lines to Lombard Substation were energized just 5 days after the existing line had been interrupted, in May 1957.

The growing power requirements on the Philadelphia Electric Company system will require expansion of distribution facilities to meet the increased demand. The development of a suitable joint for connecting pipe-type cable to existing oil-filled cable, as evidenced by the Lombard Substation project, will not only enable these new facilities to be supplied more economically, but also will allow design engineers greater flexibility in integrating these facilities into the bulk power system.

Digest of paper 58-73, "69-Kv Stop Joint for Connecting Pipe-Type Cable to Oil-Filled Cable," recommended by the AIEE Insulated Conductors Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y. Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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Railway Traction Equipment Ventilating Systems

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URBAN TRANSIT MOTORS have evolved from totally enclosed to highly ventilated designs in order to keep pace with the demand for increased performance. Successive mechanical improvements permitting higher and higher speeds, and improved fan designs on self-ventilated motors have helped to provide more air flow for cooling the windings.

Locomotive motors are generally force-ventilated because full ventilation is desirable when the motors are developing maximum rated tractive effort for long periods at relatively low speeds. The amount of air flow is decided by many factors, among them duct losses, available blower space, incremental cooling value, etc.

Ventilation is not an unmixed blessing. Cooling air entering motors and generators always carries more or less moisture, dirt, and other foreign material which is deposited in the equipment. The amount of contamination depends on a number of factors, such as volume of air, type of ventilating system, amount of filtration, and the environment in which the locomotive operates. Undesirable effects can be reduced by design measures aimed at (a) making the components more resistant to damage; (b) preventing accumulations of foreign matter in critical locations, and (c) cleaning the air before it enters the machine.

Contaminated air flowing through a machine will cover the exposed surfaces of windings with a conducting layer that, especially if moist, can cause grounds through the insulation. Flashovers may result from dirt interfering with the free action of the brush and lever arrangement. Sand in the ventilating air may erode the insulation on field coils.

If machines are not cleaned periodically, the mixtures of oil, water, and dirt will collect until an insulation check indicates the level is no longer high enough to continue operation. The insulation resistance is restored to satisfactory levels by drying the machine and thoroughly cleaning off accumulations of dirt bridging the creepage surfaces on brushholders, armature, and field coils.

Modern high-speed self-ventilated machines are equipped with baffled commutator covers which protect the commutator and brushholders from direct contact with incoming air and which have large area openings to keep the air velocity as low as possible, mumified field coils with well-insulated connections, and special brushholders having slots in the carbon box adjacent to the brush to prevent brushes from sticking.

Many diesel–electric locomotive generators are self-ventilated. Unfortunately, they have to operate in the smoke- and oil-laden air found in most locomotive engine rooms. Improvements in insulation designs have frequently been found necessary to meet some of the worst operating conditions encountered.

Modern high-capacity axle-hung locomotive traction motors are usually force-ventilated and require separate blowers. Some degree of air cleaning may be obtained by locating the blower inlet inside the cab and drawing air through louvers in the locomotive side sheets or roof. Many diesel–electric locomotives employ car body filters of the impingement type to clean the air entering the cab. Built-in air cleaners on blowers of both radial and axial flow types have proved helpful in keeping water and snow out of the motors.

Blowers for ventilating electric equipment on diesel–electric locomotives frequently draw air from the engine room. The purity of this air depends on a number of factors, such as the type and condition of filters, condition of the diesel engine, etc.

Equipments on multiple-unit cars operated from a 3,000-volt overhead system are usually self-ventilated. The air is cleaned to some extent by the use of a settling chamber if space permits. Air is drawn in at car roof level, then passes through a settling chamber under the carbody and into the traction motors. Much of the foreign material is deposited in the chamber, and clean ventilating air is delivered to the motors. Inasmuch as this system does not remove moisture, it is still necessary to insulate the windings to withstand occasional periods of wetness without developing grounds.

The centrifugal type of air cleaner is most adaptable to motor–generator sets, the air cleaner being mounted on one end and the fan drawing air through the set at the other end. This method has been used extensively on sets for 3,000-, 1,500-, and 600-volt systems. Some initial troubles were experienced because of failure to provide adequate protection from snow and moisture when the sets were shut down. Better enclosures around the fan end of machine and improved brushholder insulators corrected this condition.

The advantages of clean ventilating air for electric traction equipment are obvious as far as increased reliability and reduced maintenance are concerned. The choice of a system for a particular application should be based on economic and practical considerations. Existing air cleaning systems provide various degrees of protection against water and dirt in the cooling air, but still leave something to be desired.

Further improvements can be made in two directions: the supplying of cleaner air, and increasing the volume of air. Progress in these areas will be reflected in economic gains.

Digest of paper 58-507, recommended by the AIEE Land Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE–ASME Railroad Conference, Cleveland, Ohio, Apr. 9-10, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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Human Factors in Engineering

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The opportunities open to engineers to move into positions of management are hampered by a lack of knowledge of the requisites of leadership and ignorance of the art of human relations. Basic rules are set forth that to be effective must be put into practice until they become habit.

THE ENGINEER is often pictured as the man with the slide rule, a man of figures and facts. Actually this is only half of the picture, for everywhere he turns the engineer must deal with people—other engineers, the salesman, the shop man, his own boss. To do his job well, to win acceptance for himself and his ideas, the engineer must be able to deal effectively with all these people.

Today, the engineer is more than ever a team worker. Engineers are teamed with scientists to work on development problems, and with sales and shop people in the planning and production of apparatus. They are called on to deal with customers on complex application and operating problems.

In this highly technical industrial and military world, the engineer is in a unique position to provide leadership. He is the man with the facts, the analytical methods, the creative mind. It is natural then that many engineers move into management jobs. All experienced engineers often need to exercise leadership. Some engineers are natural leaders. Each of us has probably known at least one man with whom everyone likes to work and whose ideas are always well received. It is worth a great deal to any organization to have people like this. And the individual has the satisfaction of making the most of his other abilities and of leading an effective and pleasant life.

Many engineers, however, fail to develop these qualities as they advance technically, and some are never able to realize their full potential. Few engineers have had formal education in human relations and many have concentrated so much on their technical work that they have not benefited fully by their experience in this field. The authors as engineers recognized this need and decided to try an experiment. Discussion type classes for a group of engineering supervisors were organized drawing initially on personal experiences but adding new ideas and refining old concepts evolving from the wide experience of these men.

Later, similar classes were held with all levels of engineers participating. Over 100 supervisors and about 400 engineers attended such classes at East Pittsburgh, Pa. Even though the classes were held in the evening, 80% of those to whom it was offered attended, indicating the strong interest of engineers in this subject. Although results of such an experiment are difficult to measure, observations by ourselves and other supervisors indicate noticeable improvement and increased confidence in many of these men.

The positive results of this experiment encourage the authors to offer a brief description of the approaches used and the material evolved. This is offered in the hope that after testing these factors against their own experience, others may find them helpful.

Having been exposed to some of the best inspirational lecture courses on the one hand and purely case study courses on the other, it was felt that a different approach was needed. Engineers often respond negatively to the high pressure inspirational lecture, especially if there is the slightest suggestion of insincerity. Case studies are good, but alone are not sufficient; the engineer wants to understand the principles as well as the practice.

It was felt that it was necessary first to help these engineers realize their need, then to review a few fundamentals, and proceed to evolve from their own experiences and observations some rules of good practice. In the classes held, the leader encouraged a maximum of participation but guided the discussion and summarized the points made.

After reviewing the need, the initial approach was to ask them to study people they had known who were very effective in dealing with others, describing them and listing their qualities. The next approach was to study objectively their own reactions to specific acts of others. Throughout the course, they were continually asked to recall their own experiences and feelings. Homework was also assigned where they were asked to practice some of the principles, emphasizing sincerity and a personal interest in the other person. A case study or two were included, with the leader avoiding the expression of his own opinion. Cases generated lively discussion and brought out a variety of points of view.

Included early in the course was a brief review of elementary psychology, dealing with human behavior as influenced by basic drives and wants, and also by ideals and principles. Most engineers are familiar with the basic drives. But being generally individualistic, they are not as conscious that the needs for recognition and for acceptance by the group are very strong motivation for most people, and may even be influencing their own actions.

The common elements of human behavior were

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, Feb. 2-7, 1958, at a session sponsored by the AIEE Management Committee.

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emphasized rather than the differences. Personality differences were discussed briefly in terms of introvert and extrovert tendencies and as to degrees of emotional control and degrees of self interest.

With this preparation, some rules of good practice were evolved from their own experiences. Recognizing good practice in others still leaves the problem of making these practices a part of ourselves so that we use them with naturalness and sincerity. Without this, the effect is negative. For this reason sincerity and a true personal interest in the individual were stressed.

With these essentials in mind, let us consider some of the rules evolved. You may find nothing new here, but it is still worth any engineer's time to test these points against his experience.

RULES OF GOOD PRACTICE

Sincere interest in others. Develop a warm interest in all the people with whom you deal. People respond to genuine interest in themselves, their work, their families, their hobbies. Moreover, you benefit substantially too—not only by acquiring broader interests, but also by the personal satisfaction gained. When this warm interest in people becomes habit, any individual subconsciously applies a great many effective techniques in dealing with others.

A feeling of importance. This is a strong human want in most persons. Therefore, if we recognize that the other fellow is important, and make him feel that way—without resorting to insincere techniques—a receptive attitude may well result. Little things—like remembering his name, a sincere compliment, or an expression of confidence—help bring the other person close. Too often these important "small" things in daily contacts are overlooked or forgotten.

Be enthusiastic. Enthusiasm is contagious and inspires others to greater effort. Too often, enthusiasm is hidden behind a cloak of "sophistication," although inwardly a high enthusiasm is felt. Along these lines, a point worth remembering is that with some people a critical attitude is an indication of interest that can be turned into enthusiasm.

Maintain a positive attitude. Engineers must be analytical and critical of error, but they also have to get things done. Others respond much better when things are put in positive terms. By taking the positive approach, we help ourselves as well as others to find the best answer.

Give others a challenge. This often inspires and motivates people to their highest efforts. People usually respond with their best when they know someone has confidence in them. When faced with a difficult problem, a challenge may whet the imagination or kindle desire for achievement.

Many additional rules could be devised. A few might be: let the other fellow save face, consult with others, and show respect for their ideas. We should not attempt an all-inclusive set of rules, for human relations is an art, not an exact science.

To some, the rules outlined here may represent too mild an approach, not suitable for all cases. One engineer has suggested three approaches to dealing with others: (1) the personal interest approach; (2) the objective, or impersonal, approach; and (3) the hardboiled "do it or else" approach.

Up to the present time, only the first has been discussed. The objective approach can be used in many daily contacts where the other person is already interested and is ready and willing to do what is right. It may also be useful to us at those times where there is danger of losing control of our emotions. At such times, one ex-engineer says he tried to get this objectivity by thinking, "How will this situation look to me a week from now after things have cooled off?"

The "hardboiled" approach is one an engineer should rarely need, for he is usually dealing with reasonable people. But in rare cases you may encounter a person so ruthless that he will not respect you until he is shown that you will not be stepped on or ignored. Often we misunderstand another's motives unless we know him very well; hence, the other fellow should be given the benefit of the doubt.

The "hardboiled" approach as a means of driving people through pressure or fear is poor motivation, especially when dealing with creative people. Resentment or fear of failure tend to inhibit creative thought and distort judgment.

Interest in the other fellow and consideration of his ideas do not weaken your position nor make you any less forceful. Actually, an atmosphere of free interchange of ideas helps to gain co-operation and support. If, by listening to the others, you learn something, and occasionally admit to a mistake, people will respect you for an open mind.

COMMUNICATIONS

One important aspect of human relations is the much-discussed subject of communications. What and how much to communicate up and down the line are worth considerable thought, but most important is the subject of how to communicate. Engineers have a problem common to any specialist, that of "talking the other fellow's language." The engineer must put himself in the other fellow's place to find the concepts and the words to put his technical ideas across. This applies whether he is talking to the shop man or the manager.

The art of listening is also an important part of good communications; it forms the "feedback." The response of the other fellow must be sensed in order to regulate and guide our own expression. Observing his voice and expression, as well as his words, places us in a much better position to control the situation than if we just plunge ahead blindly with our own thoughts and feelings. This sensitivity to others' feelings is one of the basic points of the human relations skill and is worth cultivating.

Part of good communications is effective presentation. Engineers are already good at logical thinking and organization, but not always adept at expression or

salesmanship. Presenting a proposition or making a request is really an attempt to sell our ideas and ourselves.

Here is an effective sequence or a check list to help us organize our thoughts and actions:

Get a receptive mood. It is often worth a few minutes time to get the other fellow in the proper frame of mind.

Get attention. Start in an area of mutual interest, related to the proposition.

Build interest in the subject. State the subject clearly and show him why he should be interested.

Build desire. Appeal to his wants and to his principles, to his reason and to his emotions. If you can, dramatize with a human interest story (to the point), and lead his imagination. But use judgment, don't oversell.

Leave a clear understanding of what is to be done. Get him to state what he will do, summarize it yourself, or give a command—whichever the situation demands.

LEADERSHIP

LEADERSHIP is one phase of human relations in which everyone is interested. There is a good deal more to leadership than just getting along with people, being persuasive, and having good communications—although these are certainly an important part. Integrity is obviously a most important quality of leadership; but there are other qualities of an effective leader.

Respect of the group. People like to be led, but they want their leader to have at least one strong point—such as ability, or diplomacy, or courage. Whatever the quality, it must be something that other people recognize. No one should hesitate to stress his own strong points; however, this necessitates greater amounts of tact, diplomacy, and understanding. Make your good points show, but not to the point of being overbearing or inconsiderate.

Willingness to take responsibility. Again, others are usually glad to let you take the responsibility if you demonstrate the ability and the willingness, without being over-eager or reaching far beyond your ability.

Ability to create a team. People like to be a part of a good team. You as the leader have to demonstrate your interest in the group as a team and let them know what you expect of them as part of your team in accomplishing the objectives of the group.

Competition with another group tends to build team spirit but it can also work against co-operation. Competition with the accomplishments of another firm in the same field or with your own previous record is excellent.

Ability to correct faults tactfully, without discouraging others. No one likes criticism, but most people will accept correction, in private, if you display understanding and are just in your comments.

Devotion to the cause. It must be evident that you believe in your stated objectives; then your example will be a major factor in motivating others. Enthusiasm is contagious and perseverance provides stability in time of difficulty.

Intellectual courage. In engineering leadership, you must face all of the stubborn facts, weigh the risk of the unknowns, and make a decision. People respect and will follow an engineer who has a purpose and a plan, and the courage to act on his convictions.

CONCLUSION

SERIOUS EFFORT TO IMPROVE our human relations is worth while. Engineers can be more effective on the job—they can have their ideas more readily accepted and their counsel more eagerly sought. The keys to actual improvement are sincerity and practice. This involves remembering to do something about it at every opportunity. "Become interested in the other fellow" is an important objective. A warm human interest assures the right attitude towards others. This interest will help to open the door to better communication and it will bring to mind the other techniques that can contribute to effective dealings with people.

These objectives warrant the best efforts of any individual engineer. Much help can be derived from organized group discussions such as those described. Engineers are interested in this subject and once they see the need and the way to improvement they will respond to this direct approach to improved human relations.

400 Mile Spinal Cord

More than 400 miles of wire serve as the spinal cord of General Electric's Switchgear Development Laboratory in Philadelphia, Pa.

Contained in metal-lattice trays, the wire runs in this underground tunnel between the laboratory's control room and test buildings.

The multiwire cables connect the intricate controls with the power equipment and measuring devices used for testing circuit breakers in five test cells of the test building and the high-voltage yard.

Balancing Reactors for Semiconductor Rectifiers

I. K. DORTORT
MEMBER AIEE

THE ADVANTAGES of semiconductor diodes in certain applications of d-c power have led to the design and construction of rectifier units of very high current ratings, employing many diodes in parallel on each phase of the rectifier transformer. As in the case of mercury-arc rectifiers having more than one anode connected to each phase, the designer is faced with the problem of current unbalance between parallel elements.

Although the major causes for current unbalance in the two types of rectifiers are quite different, balancing reactors serve in either case to force proper current distribution. These reactors resemble each other physically, but their mode of operation is different. Moreover, the large number of semiconductor diodes often connected in parallel will generally dictate very different arrangements.

Heretofore, little use has been made of balancing reactors for germanium and silicon rectifiers because of a lack of appreciation of the over-all economy that can be achieved. Recent developments and performance require a new evaluation of the solutions available. They cover the entire spectrum from completely natural current distribution to forced current balancing of high accuracy. The following listing, with annotations, offers a quick review of the methods used, their merits and limitations.

Natural current distribution. Effective to any reasonable extent only when several diodes are connected in series and the series strings paralleled. Statistical variation offers some balancing effect depending on the number of diodes in series. Unbalance tends to get worse with increasing load and temperature.

Forward drop matching. Use of matched diodes requires careful coding and replacement of diodes with new diodes in the same code group. Characteristics matched at one load may deviate with changes of load and temperature and possibly with time.

Ballast resistors. Effective only when the resistance drop is made a significant part of the total drop. Losses are increased in proportion. When used with coded diodes, the resistance drop of protective fuses may assure sufficient balancing.

Derating factors. With any of the preceding three methods, derating factors are generally applied as some function of the number of diodes in parallel, to reduce the percentage of failures caused by overloaded cells.

Current balancing reactors. The use of balancing reactors deserves careful consideration, not only from the standpoint of technical correctness, but as a matter of economic advantage. In this respect, we must not overlook continuity of service and cost of maintenance.

The small voltage differences between similar diodes, and the size of conductors required in power equipments, make the through-type of reactor construction very attractive from the standpoint of losses, space, and economy.

Such reactors make it relatively simple to balance each diode against its immediate neighbor in "chain" fashion as shown in Fig. 1. The maximum difference between the peak currents of two adjacent anodes cannot exceed the magnetizing current of the magnetic loop threaded by their leads.

Both open- and closed-chain reactors have been constructed of multiple-punched strips of transformer steel. The closed-chain arrangement, made up of two stacks of the punched laminations shown in Fig. 2, lends itself particularly well to rectifiers having many cells in parallel.

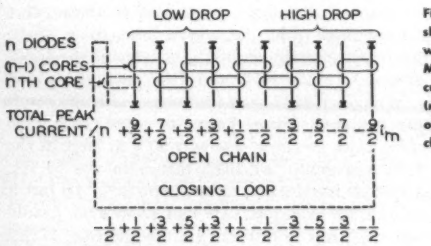

Fig. 1 (*left*). Chain of reactors showing current unbalance with worst distribution of diodes. Maximum difference of peak currents with open chain is $(n-1)\ I_m$; maximum difference of peak currents with closed chain is $(n/2)\ I_m$.

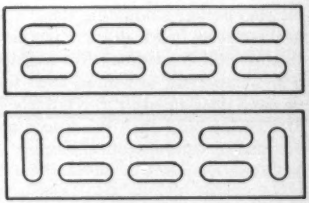

Fig. 2. Punched-strip closed-chain reactor.

Digest of paper 58-219, "Current Balancing Reactors for Semiconductor Rectifiers," recommended by the AIEE Semiconductors–Metallic Rectifiers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.
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The Demand for and Supply of Engineers and Scientists

W. T. CAVANAUGH

Today's engineering and manpower situation is appraised by means of information and techniques gained in the past few years. Estimates of trends based on latest available figures are presented.

THE PROBLEM of technical manpower has been with us in an obvious way since the outbreak of hostilities in Korea. Most people and many interested organizations have viewed it as a finite problem that could be neatly labeled and then handled in accordance with some appropriate, if elusive, formula. There has been perhaps too little realization of the fact that the technical manpower situation in all of its aspects is at once complicated and fluid.

The most basic and important element in the supply of engineers in any given year is, of course, the size of the engineering graduating class. This is especially true in those years in which there is something approaching absolute full employment for engineering personnel. It is also important at a time, such as the present, when we have what amounts to relatively full employment of engineering personnel. We should also concede the fact that people without college degrees do, to some extent, make contributions in the total engineering tasks to be accomplished. The number of these individuals roughly offsets the number of those who, having had an engineering education, are not seeking engineering employment as such. Also, it is very clear that organizations having engineering manpower needs increasingly turn to engineering schools as their primary and numerically preponderant source. When the EJC (Engineering Joint Council) annual manpower studies were begun some years ago, they were studies of demand for engineering graduates. They assumed this limitation largely because of the great difficulties involved in any other approach. The trends of the years since, however, have indicated the increasing realism of what was initially a utilitarian and somewhat arbitrary decision.

The second important step in gauging the supply of engineers is an analysis of the impact of factors which affect the availability of engineering graduates for engineering employment. The most important item here is the impact of various military service programs and regulations.

Revised text of an address presented at the New Jersey Conference on Utilization of Scientists and Engineers, Rutgers University, New Brunswick, N. J., Apr. 2-4, 1958.

W. T. Cavanaugh is executive secretary, Engineering Manpower Commission of Engineers' Joint Council.

ENROLLMENTS AND GRADUATES

IN 1954 there were 22,174 B.S. degrees in engineering awarded in the United States. The EMC (Engineering Manpower Commission) estimates that during the academic year 1957-58 about 34,500 Bachelor's degrees in engineering will be awarded. It may be interesting to note that this estimate for 1957-58 represents a scaling down of estimates made a couple of years ago. This reduction is required by an analysis of recent trends in the relationship of engineering graduating classes to their freshman classes four years earlier. For example, the 1950 freshman class in engineering—the key factor in the 1954 graduating class—registered amid the "gloom and doom" talk of early 1950 about the future of engineering careers. There was, therefore, a small freshman group numbering about 34,300. Inasmuch as these men made their choice under these circumstances, it may be assumed that their orientation to engineering was of a very high order. Four years later, the graduating class in engineering was 62% as large as the freshman group. In 1951, 1952, and 1953, attitudes about careers in engineering began to change, with the result that the freshman classes began to grow. The 1956 graduating class, however, was only 50% as large as the 1952 freshman group. In 1957, this ratio was 51.5%, and in 1958, it is estimated to be about 52%. To put it another way, for example, 1956 had 4,056 more graduates than 1954. But in order to get this increase, 17,322 additional freshmen were necessary. It appears, therefore, that estimates of graduates will have to be revised downward by roughly 10% until such time as there is evidence that mortality rates can be reduced.

MILITARY SERVICE

THE NEXT FACTOR needing analysis in the determination of the engineering input into the work force is the impact of military service programs and regulations on the engineering graduating class. Since we have had now for about a decade programs which regularly divert a significant proportion of our engineering graduating classes into military activity, there exists a ratio of people returning from military service to those entering the service. Until about 1956, these two factors tended to balance in a rough way. Since 1956, however, the elements of this ratio have changed in favor of nonmilitary activity. In other words, we had in 1957 and will have in 1958 a significantly larger number of people returning from military activity than are entering such activity. We have to consider that this

year, those ROTC graduates and selective service inductees of 1956 will, for the most part, be returning to civilian activity. In 1956, approximately 11,000 engineering graduates entered military service. This year, these 11,000 will be returning to nonmilitary activity whereas only about 6,000 of the 1958 engineering graduates will be entering military activity for substantial periods. Obviously, therefore, we have a net gain of about 5,000 engineers to the work force, which must be added to the 34,500 engineering graduates of this year's class.

The final factor is, of course, the impact of graduate enrollment and graduate degrees granted. In addition to the baccalaureate degrees for 1958, there will be awarded approximately 600 Ph.D degrees in engineering and about 5,700 Master's degrees. In prior years, the number of graduate degrees was not considered a net addition to the total output for the year because about the same number of Bachelors went on to graduate training. There are, however, indications this year that, thankfully, an increasing number of the Bachelor engineers will enter full-time graduate work. This year there will be a net deduction of about 1,500 Bachelors from the full-time engineering force.

All this adds up algebraically to an estimate that this year we will have available for engineering employment approximately 38,000 new and recent graduates, the largest net addition to the engineering force we have experienced since academic year 1950-51. The same general trends exist to a more modest extent in the physical sciences and mathematics.

STUDY OF DEMAND

THE 1956 EJC Study of Demand for Engineering Graduates, which indicated a very high level of unfilled demand, nevertheless warranted the following conjectural conclusion: "Looking ahead to the next three years when the size of the graduating class will average about 35,000 per year, it is pertinent to note that this increase in the size of the graduating classes combined with a somewhat reduced technological momentum may have the effect of easing the present situation of extreme shortage. On the other hand, it is clear that given continuing technological activity with a growth factor similar to that of the recent past, there is very little to promise merely numerical relief during the next three years."

The 1957 Survey indicated that the first of these two alternatives was occurring. The year 1957 had a net addition to the engineering force of about 33,500. The over-all conclusion of the Survey was that as a result of the increased net supply—up about 20% over 1956—and the leveling off of recruiting goals, demand as expressed by these goals was substantially met at the Bachelor level in nongovernment employment activities. In short, there was a discernible shift down from a high level of demand to another level still relatively high. It should be mentioned that the Survey in 1957 was made late enough to catch the effects of the pre-Sputnik Defense Department cutbacks and stretch-outs.

It is our current judgment that the characteristics of the 1957 situation are still controlling factors. This is confirmed by Frank Endicott's 1958 report, by the lower tempo of campus recruitment efforts, and by sketchy information available on probable starting rates for college graduates. The amount of increase over 1957 is apparently small, and probably more the result of internal forces in salary administration than of factors arising from competition.

The over-all conclusion to be drawn here seems to be that the recruitment of new and recent engineering B.S. graduates can be more productive during the next few months in terms of both quality and quantity than during any period since early 1950, despite the fact that the level of demand is still relatively high. An important exception is the recruitment of PhD.'s in engineering. The supply is hopelessly deficient when compared to the needs of industry and engineering education, although this is partly compensated by recruitment of Ph.D.'s in the physical sciences and mathematics.

LATEST TRENDS

THERE ARE one or two additional points that may contribute to our thinking about the problems. The employment situation for engineers and scientists has shown great relative stability and strength and, in general, a most impressive ability to reabsorb those really qualified people who have been displaced. It is my opinion that those who see in the events of the past 10 months anything other than a temporary dip in a long ascending curve are erring seriously in a direction that—all things considered—can do grave harm.

There is one definite indication that the current situation may be of very short duration. Recently obtained figures from the United States Employment Service on trends in their Professional Placement system admittedly show only a fraction of requests for professional personnel. Its monthly clearance lists, however, provide a reliable over-all index of employment trends. For the past year, the engineering index has been gently declining.

As yet unpublished figures indicate that a sharp reversal took place in this trend beginning early in February. For each 2-week period since February 1, there has been a sharp increase in the number of available engineering positions. The total number of jobs in clearance has increased 57% since then. Analysis of the openings indicates that they are well spread across the spectrum of specialty. This same trend has occurred in openings for physical scientists.

Although this was expected as a partial result of the impact of new defense research and development funds, the trend was expected to begin reversing in May or June. It is my expectation that this trend will accelerate rapidly and, barring a further serious dip in the general economy, produce a very tight engineering and scientific manpower market by midsummer. In short, it appears that 1958 in its technical manpower trends will be the opposite of 1957, a year which began high and ended in a relative decline.

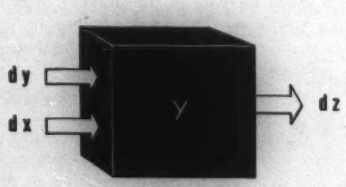
DDA—What Is It?

R. N. GOLDMAN

The DDA or Electronic Digital Differential Analyzer provides a simple means for programming the numerical solutions of problems which can be expressed in the form of ordinary differential equations. This includes linear and nonlinear simultaneous equations, solutions for roots of transcendental equations, and the simulation of many real systems.

THE BASIC PRINCIPLES of a differential analyzer for the solution of differential equations are not new. Fundamentally, such a machine consists of a number of integrating mechanisms, connected together so that the assembly can be constrained to solve any type of ordinary differential equation. The interconnections are easily determined from the terms and relationships in the equation. These ideas were first described by Lord Kelvin in the Proceedings of the Royal Society over 80 years ago. His brother, James Thomson, actually constructed a mechanical disc, ball, and cylinder integrator. Dr. Vannevar Bush, 30 years ago, designed and constructed a working mechanical differential analyzer at the Massachusetts Institute of Technology. And soon after, naturally, the Soviets (by 1940) had one built and operating in Leningrad. These mechanical analog computers were followed by electronic analog designs in which integration is performed by voltage change; time, therefore, becomes the independent variable of integration.

The DDA was developed in an effort to eliminate disadvantageous features inherent in the use of general-purpose or analog computers. Specifically, the DDA is much easier to program than a general-purpose computer would be and is much more accurate and versatile than an analog computer would be. The action of a DDA can be simulated on a general-purpose computer, but, if that is done, a high-powered and highly expensive piece of equipment would be necessary in order to do what could be done by a much less costly special-purpose device.



$dz = k\,y\,dx$

By the accumulation of dz's: $z = k\int dz = k\int y\,dx$

Fig. 1. An integrator in the DDA.

The DDA of the present day is functionally a hybrid. It handles information and performs arithmetic operations digitally, as would a general-purpose digital computer, but its programming is based on the same concept of integrators which forms the foundation of the mechanical and electronic analog differential analyzers.

HOW DOES THE DDA WORK?

AN INTEGRATOR in the DDA may be thought of as a black box (Fig. 1) which has two input lines and one output line. The black boxes may be interconnected so that the output lines of some integrators become the input lines of other integrators.

The inputs to an integrator are dy and dx, differentials of dependent and independent variables in the problem to be solved. The output is the differential dz calculated so that $dz = k\,y\,dx$. The value y, which is the accumulated value of the dy inputs, is held in a register within the integrator. Therefore, if the output line of the integrator is connected to the dependent variable input line of a second integrator, we may obtain in the y register of the second integrator $z = \int dz = \int y\,dx$. By programming the interconnection of integrators of this nature, and by selection of initial values for the y terms in each, any ordinary differential equation may be solved.

The action of an integrator is explained graphically in Fig. 2. Let us consider the evaluation of the definite integral of y_m with respect to x by continuously accumulating the area under the curve $y_m = f(x)$ as x increases. Initially, the curve is at point y_o, x_o. The curve is approximated by incremental changes in y and x. The incremental changes Δy and Δx are small in terms of the numerical values involved and usually are referred to by the differential terms dy and dx. If y_m is the instantaneous value of y, each time x increases by one dx increment, a rectangle of width dx and of height y_m will be added to the accumulated area. The incremental changes in y_m, which may consist of from one to several increments at a time, may be rounded off in a manner which reduces the triangular error made

Essentially full text of a conference paper "What Is a DDA?" presented at the AIEE Winter General Meeting, New York, N.Y., Feb. 2-7, 1958. Recommended for publication by the AIEE Computing Devices Committee.

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at the tops of the rectangles. Although we must keep track of the value of y_m in order to know how high a rectangle to add with each dx change, we need not keep track of the entire accumulated area. We may simply send out notification each time an increment of area has been covered and allow the total area to accumulate elsewhere. It will then be necessary to keep track of only y_m and of any fractional part of an increment of area. On the slide we consider that a rectangle of width dx and of height $+1$ (the full height of the diagram) is the increment of area represented by a dz pulse.

It is in this manner that a DDA integrator operates. The dx input notifies the integrator each time that the independent variable x has increased or decreased one increment. The dy input notifies the integrator of the corresponding changes in the dependent variable y_m. An output pulse dz is generated each time an increment of area has been traversed. The instantaneous value of an incremental input or output is always $+1$ increment, -1 increment, or zero. If the dz line is fed into another integrator as its dy input, this second integrator will then contain as its y value the total instantaneous value of the area Z.

Fig. 3 shows what is in this black box called an integrator. It contains two numerical registers, as shown in the figure. One, called the Y register, algebraically accumulates the value of y_m. The other, called the R register, contains the fractional part of an increment of area; the numerical value in the R register will range between zero and one increment.

The actual digital operation is accomplished in a straightforward manner—dy increments are added to y_m algebraically. Each time a dx pulse is received, y_m is added to the number which exists in the R register. Inasmuch as neither register is cleared in the process, the R register will overflow periodically. It is the overflow of the R register which causes the dz output signals. Each dz pulse corresponds to the increment of area used in the graphical illustration.

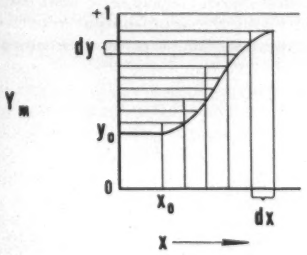

Fig. 2. Graphic illustration of the action of an integrator.

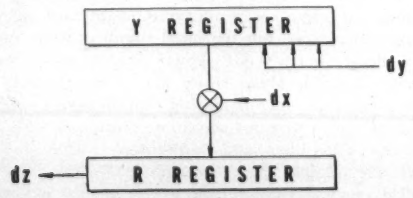

Fig. 3. Contents of an integrator.

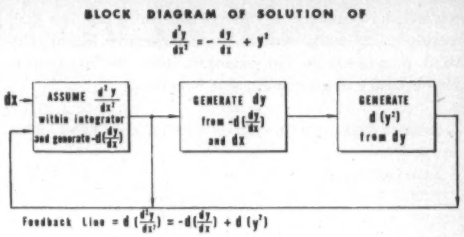
BLOCK DIAGRAM OF SOLUTION OF
$\frac{d^2y}{dx^2} = -\frac{dy}{dx} + y^2$
dx
ASSUME $\frac{d^2y}{dx^2}$ within integrator and generate $-d(\frac{dy}{dx})$
GENERATE dy from $-d(\frac{dy}{dx})$ and dx
GENERATE $d(y^2)$ from dy
Feedback Line = $d(\frac{dy}{dx}) = -d(\frac{dy}{dx}) + d(y^2)$
EACH BLOCK REPRESENTS ONE INTEGRATOR

Fig. 4. Use of integrators to program the solution of a differential equation.

In most DDA's, in order to economize on hardware, integrators are processed serially; that is, the same electronic components are used for each integrator and a fixed sequential counter determines the number of the integrator currently being processed. As a consequence, the time required to compute a solution is not a function of the number of the integrators used in the program, but is a function of how soon incremental inputs to integrators cause incremental outputs. The amount of variation in the y value, or integrand, to be represented by a single incremental input is optional. Naturally, the smaller this incremental variation in the integrand is made, the greater the precision of the solution. Each additional digit of precision desired increases the time required to compute a solution.

HOW IS A SOLUTION PROGRAMMED?

How integrators can be used to program the solution of a differential equation is shown in a simple example in Fig. 4. The approach which is used to program the solution is to isolate the highest order derivative in terms of the other variables. The existence of this derivative in an integrator is assumed and, by repeated integration, is used to provide all the lower order derivatives. The lower order derivatives are then combined according to the conditions of the equation in order to find the highest order derivative assumed to be in existence. A closed loop results in which the solution is implicit and from which numerical values can be obtained for selected time intervals.

This problem is, of course, a trivial one. Problems may be handled with many more terms, with constant multipliers, and with empirical functions, if desired. Mathematical functions may be internally generated. Algebraic, trigonometric, exponential, logarithmic, hyperbolic, Bessel, and probability functions may all be

generated by integrator interconnection. Function generation is a straightforward process easily learned by DDA programmers. For example, only two integrators are necessary to generate a sine function.

HOW IS THE USEFULNESS OF THE DDA EXTENDED?

THE VERSATILITY OF THE DDA is extended by providing a second mode of integrator operation in which the dz output is determined differently. In this mode, the integrator has an incremental output whenever the y register within the integrator has a nonzero value and a dx input occurs. This mode is called "decision" operation and is useful in simulating the action of a servo, in providing means for the addition of functions, and in handling discontinuities in functions. Just two decision integrators, for example, would be able to generate a saw tooth wave form. The discontinuities in the curve will occur at the moment the y register becomes zero. Other DDA features further extend versatility of the equipment. In some machines, after computation has begun, a new set of initial conditions may automatically be inserted in the integrators and the problem recomputed with new parameters.

Fig. 5. View of Bendix's combination general-purpose computer and digital differential analyzer.

Users of electronic analog computers will be interested in noting that in the DDA not only is precision much greater than in the analog analyzer but a wider variety of functions may be generated and equations simulated. This is true because in an electronic analog computer the independent variable input to an integrator must be time; a limitation which does not exist in the DDA. The independent incremental input to an integrator may be the output of any other integrator.

In conclusion, a recent development in DDA technology should be mentioned. The Bendix Computer Division has placed on the market a combination general-purpose computer and digital differential analyzer (Fig. 5). The analyzer can be used in conjunction with the general-purpose computer for the programming of highly involved problems. Split boundary value problems, for example, are within the scope of the equipment. Empirical function input may be from any of the computer's digital input devices or from a graph follower. In this combination machine, the differential analyzer makes use of a portion of the magnetic drum memory of the general-purpose computer in order to hold integrator information. The DDA portion of the equipment provides 108 integrators and 108 additional constant multipliers. Seven decimal digits precision is provided in each integrator.

Earlier DDA's combined the ease of programming of the differential analyzer with the precision of digital computation. The new Bendix equipment adds the power, the versatility and the input–output convenience of the general-purpose computer to these other advantages.

"Retired" Transformers

Two electric power transformers, in a Brooklyn shipyard almost as long as the Dodgers in Ebbetts Field, were recently "retired" after 56 years of service.

The antique transformers supplied 25-cycle power for a large floating dry dock until the shipyard recently converted it to 60-cycle power.

Shipyard officials were uncertain as to how old the transformers were, but the serial numbers were traced in General Electric's (GE) Power Transformer Department, Pittsfield, Mass. Dusty files dated January 7, 1901, revealed manufacturing specifications giving turns of copper wire of a certain size, insulated with cotton tape, oiled linen, and "hornfibre."

Of the original three single-phase 300-kw units installed, one was removed from service in 1956 and other two carried 160% rated load until the end of 1957.

The Electrical Industry in Mexico

A. W. GELBKE
MEMBER AIEE

Discussion of the background and growth of the electrical industry in Mexico showing the factors that assure the area an accelerated rate of development in which electric energy is playing a key role.

MEXICO, our neighbor to the south, has been developing rapidly from a country having a predominantly agricultural and mining economy to one in which industry plays an increasingly more important role. With an area of about one fourth that of the continental United States and a population of 31.5 million people, it is geographically half in the Temperate Zone and half in the Tropics; but, because of the altitude of the central plains more than 70% of the people live in a temperate climate similar to that of the southwestern United States.

Prior to World War II, Mexico's industry consisted principally of textile mills, tanneries, soap manufacturing, food and beverage processing, and the beginnings of a cement and steel industry. Electrical equipment was supplied by importation from Germany, the United States, England, Switzerland, Sweden, and Japan.

The outbreak of World War II, in which Mexico joined on the side of the United States, was a major factor in the advance of Mexican industry. Supplies and spare parts for the machinery already installed were no longer available from Europe and, to keep this equipment operating, the necessary parts were made in Mexico, the beginnings of a process which continued until skills, materials, and methods were developed to a point where local manufactures were equal to or better than the imported ones for use under local conditions.

Direct railroad and highway communication between Mexico and the United States provided a close link between the two countries free from the hazards of wartime marine transport. Mexican copper, tungsten, manganese, and other strategic minerals were shipped by rail to the United States in exchange for capital goods to further the development of manufactures and industries in Mexico using locally produced raw materials.

From that time on, Mexican industry has been operating continuously under boom conditions. A chain reaction was started as the population shifted from a mainly agricultural one, in which few people had income above a subsistence level, to one in which a large number of people were paid in cash at a high enough rate so that they could acquire radios, television sets, refrigerators, and the other electrical appliances that previously had been within the buying capacity of only a very few. In short, they became consumers and broadened the markets for the products of the industries in which they were employed. The development of Mexican industry is similar to that which took place in the United States in the late 1800s, but its rate of development is enormously accelerated by the use of the powerful tools and modern materials available to it that were primitive or nonexistent while the United States was in the same stage of development.

Essentially full text of a conference paper presented at the AIEE Southwest District Meeting, Tulsa, Okla., March 31–April 2, 1958, at a session sponsored by the AIEE Power Generation Committee.

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KEY ROLE OF ELECTRIC ENERGY

THE MOST POWERFUL TOOL available for the growth of industry and for the bettering of the economic position of the workman is electric energy supplied by the public utilities of the country. These utilities, beginning in the late 1800s with small hydroelectric plants for lighting service, have grown at the average rate of 12% per year to a present installed capacity of 2.211 million kw and there is every indication that this rate of growth will continue. The three major electric utilities–Federal Electric Commission (government owned), Mexican Light and Power Co. (privately owned), and Compañía Impulsora de Empresas Eléctricas, S. A. (privately owned)–are co-ordinating their expansion programs with this growth in view. Compañía Impulsora which is a subsidiary of American and Foreign Power Company, has completed plans for a $160 million expansion program over the next 8 years. It replaces the 1955 five-year program of $40 million which has been revised to keep up with Mexico's rapid industrialization. All the projected increase in generating capacity by the privately owned utilities is in thermal power plants. Hydroelectric plants are being developed by government agencies to utilize water for power generation and irrigation.

Concurrently with the development of the electric generating industry there has been a rapid growth in the manufacture of equipment and devices used by the utilities for generating, transmitting, distributing, and metering electric energy. Even greater than this has been the growth of the domestic appliance industry. All the country's requirements of electric irons, washing machines, radios, refrigerators, television sets, and television picture tubes are made or assembled in the country. Incandescent and fluorescent lamps are made in sufficient quantity to supply the national demand.

Most electrical manufacturers supply equipment for industrial use as well as appliances for domestic and commercial service. The two largest electrical manu-

facturers covering the entire field are Westinghouse through its concessionnaire, Industria Eléctrica de México, and General Electric through its wholly owned factory, Manufacturera General Electric. Besides these there are large plants making wire, cable, transformers, and pole hardware such as La Consolidada, Anaconda-Pirelli, and Allis Chalmers. Carbon for brushes and electrodes is produced by National Carbon, and plastic materials are made locally by Du Pont, Monsanto, Celanese, and Bakelite.

LEGISLATION AIDS INDUSTRY

INTELLIGENT LEGISLATION intended to promote the establishment of new and necessary industries and to protect established industries from international economic pressures such as "dumping" and "cartels" has helped the electric goods and equipment industry to develop to its present capacity of 150 firms employing more than 10,000 workers and with an invested capital of over $35 million. This has been done without a monopoly on foreign exchange or exchange rationing as in many other Latin American countries. There is complete freedom of foreign exchange operations in Mexico.

Tax concessions are granted to encourage industries in the following categories:

1. Industries providing services for economically important activities.
2. Assembly operations, provided they use Mexican produced parts which represent at least 60% of the direct cost of their products.
3. Industries which will export their own finished or semifinished products, provided at least 60% of the direct production cost of such products represent Mexican manufacture.

These newly established industries are eligible for from 5- to 10-year reductions or exemptions from import duties and income taxes. They are also permitted to import their capital machinery with a very small amount of duty or no duty at all.

Most of the electrical manufacturing enterprises in the country were initiated under the protection of these laws. A further advantage given the Mexican manufacturer is tariff protection against foreign imports. As soon as a manufacturer or group of manufacturers feel that they can supply the entire Mexican market with their product they may petition the Ministry of Economy asking that the import of similar competitive articles be prohibited. If they prove their case, the petition is granted. This action has been taken on most types of electrical equipment or key parts so that, at present, the following equipment may only be imported by special permission of the Ministry of Economy: transformers (all types), motors, pumps, switches, interruptors (all types), fuses, wire and cable, domestic appliances (except heavy-duty semicommercial types), switchboards, and insulators. Transformers to 20 mva have been constructed by Industria Eléctrica and they have been impulse tested at that plant for 69-kv basic impulse insulation level (BIL).

Inasmuch as parts and materials for the assembly of this equipment may be imported freely, with low customs duties, many manufacturers have begun by assembling all imported parts. Then, as their own facilities and outside sources of supply were developed, they manufactured and purchased Mexican-made parts equal to 60% of the production cost of their product by which they became eligible for the tax reductions under the "New Industries" law.

An important factor that has accelerated the establishment of new industries has been the simultaneous development of specialized shops making screws, bolts, rivets, and other hardware, accessories and moulded parts used in electrical assemblies.

ELECTRICAL MARKETS EXPANDING

THE MARKETS FOR ELECTRICAL EQUIPMENT and appliances are expanding because of a number of positive factors, each of which tends to magnify the effect of the others. Mexico is a young country industrially and in the average age of its population. Its annual increase of 3% in population is the highest in Latin America and one of the highest in the world. Superimposed on this increase is the fact that the active population, which is at present about one third of its total population, is growing at a greater rate than the total population of the country. Because of these factors the buying power of the country has been increasing at a cumulative rate of 6% a year.

This buying power has its concentration in the larger cities particularly in the Federal District which includes Mexico City. This District has 14.4% of the total population of the country, accounts for 30% of the gross national product (GNP) and contributes 32% of the national industrial production. The Federal District has the highest concentration of electrification in the country, 98% of the families having electric service. Mexico's GNP of $8.8 billion is small when compared to the $450 billion GNP of the United States but the concentration of buying power and the convenient means of transportation within and between the industrially important sections of the country make this market attractive to the manufacturer of electrical products.

Although the general field of electrical manufacture in Mexico is an extremely attractive one, careful investigation should be made of markets, available facilities, distribution methods and competition, both local and foreign, in relation to the specific product or line of products to be manufactured. Patents, trademarks, and copyrights must be registered in Mexico and when properly done they provide practically the same protection as that provided in the United States by similar registration.

Further information on the fields previously discussed is available from Mexican Consulates in the United States, the United States Department of Commerce, Bureau of Foreign Commerce in Washington, and from the privately owned electric utilities of Mexico such as the author's company.

Airborne Teletypewriter *AN/AGC-1*

R. A. MICHALS

THE *AN/AGC-1* is a teletypewriter that has been packaged for use aboard aircraft. It is capable of receiving or transmitting messages at 60 wpm and it contains a magnetic recorder for the storage of messages and a call system for the elimination of local traffic. Electronic techniques have been used to replace many of the mechanisms used in a standard teletypewriter.

Fig. 1 shows the units comprising the *AN/AGC-1*. The system is separated into four major components. All units are interconnected by means of wires. The entire system weighs 46 pounds.

The control panel controls all the operating modes of the system; i.e., transmission by means of the keyboard or from the storage unit; reception of a message with or without the call system or the storage of a message into the magnetic recorder from the keyboard. Its size is 3 inches x 5 inches x 5¾ inches and it weighs 2 pounds.

The keyboard converts the operator information into teletypewriter form. Electrical information is obtained from contacts inside the keyboard. The size of the keyboard is 4 inches x 10 inches x 4 inches and it weighs 6 pounds.

The page printer prints its message on pressure-sensitive paper at 60 wpm. Its size is 5-1/4 inches x 5-5/16 inches x 11 inches and its weight is 8 pounds. The printing is accomplished by a typewheel and hammer. The typewheel is made to move across the width of the paper, thereby obtaining a line of characters. The position of the typewheel is sensed electronically and indexed by an electromechanical device.

The terminal unit contains all the electronic hardware for operating the teletypewriter system. The unit is 10 inches x 10 inches x 15 inches and it weighs 30 pounds. All the subminiature tubes and most of the resistors and capacitors are mounted on three removable subchassis within the terminal unit. The main chassis contains the magnetic recorder, power transformer, voltage regulator tubes, silicon rectifiers, tantalum capacitors, and relays. On the front of the case is a hinged cover for changing the call of the call system.

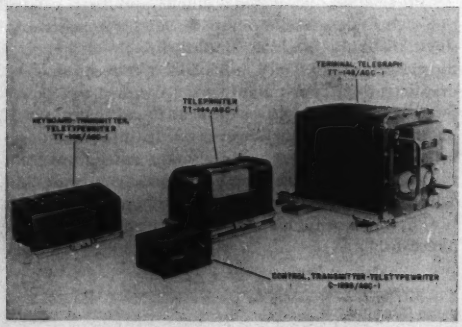

Fig. 1. Airborne teletypewriter set AN/AGC-1.

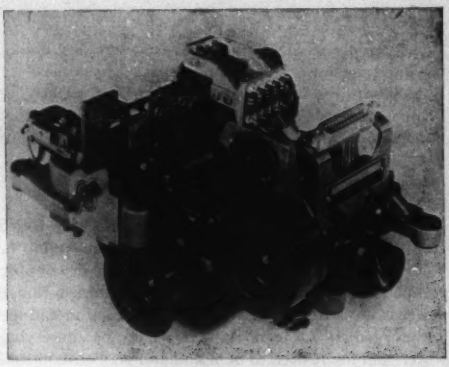

Fig. 2. Magnetic tape recorder.

Fig. 2 shows a view of the magnetic recorder. The over-all size is approximately 10 inches x 6 inches x 6 inches and its weight is 4 pounds. This device is able to store a message as typed on a keyboard, reset itself to the beginning of the message, and then supply the message (any number of times) at the transmitting rate of 60 wpm. A new message can be re-recorded any time it is desired. The tape used was made of polished spring steel, one inch wide. This tape was chosen because it could be positioned accurately after a long usage and had the property of being able to wind itself up on a take-up spool.

The tape can be seen coming off the tape feed spool, passing through the erase coil, under the magnetic playback record head, onto the tape sprocket drive wheel, and going to the tape take-up spool. In operation, the magnetic head is caused to scan across the width of the tape. The tape drive wheel then indexes the tape into position under the magnetic head, thereby obtaining the bits of information in parallel tracks across the width of the tape.

A small quantity of these units have been built for the U.S. Air Force and are now being service tested.

Digest of paper 58-47, recommended by the AIEE Telegraph Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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The Pump-Turbine Story

F. E. JASKI

Commonly used in Europe, pump–turbines are finding increased use as a source of economical power in the United States. Among their numerous advantages is their applicability in many locations not suitable for conventional hydraulic turbines.

A PUMP–TURBINE is a hydraulic machine which can be used alternately as a centrifugal pump or as a hydraulic turbine. It is used for developing pumped-storage hydroelectric power. Pumped-storage power is not a new concept. It has been used in Europe for more than 75 years. It is a means of conserving power, and has proved to be sound and very economical.

In all the power systems throughout the United States, we have a load that varies from daytime to nighttime. The greater loads come on the system during the daytime, and at night the load reduces very sharply. The peak load on the system usually occurs during the daytime, and the night load is much lower. On week ends and holidays the load is also much lower.

Throughout the world, the greater portion of electric power is furnished by thermal units, such as steam turbines. The heat for producing steam is obtained from fossil fuels such as coal, oil, and gas. For economic reasons it is very important that we conserve these fuels so they will not be depleted too rapidly.

It is a known fact that steam turbines give better economy as the size is increased. Today, steam turbines are being built for rated outputs of 300,000 and 450,000 kw. All steam turbines produce their best economy if they are run continuously, 24 hours per day, 365 days per year, at a large load factor.

The alternating day and night load produces a load curve that looks like a saw-toothed curve, with peaks in the daytime and valleys at night and on week ends and holidays. Each power system must have sufficient equipment such as steam turbines to provide power for the maximum anticipated peak load, and in addition must carry a spinning reserve to provide for breakdowns or equipment failure. It is apparent that all of these units will not be running continuously at high load factor. Some will be idle or shut down, others will be spinning at no load so as to be ready to pick up the load changes as the load increases.

The electrical load in the United States is growing at such a rate that 10 years from now we will need at least twice the amount of power that we have today. More and more of the larger size units will be needed.

Now, in order to keep as many units as possible loaded continuously, we must improve the load curve. With increase of power, the peaks keep going up, but the valleys are not coming up at the same rate. Therefore, if we can find a means of building up the valleys, we will flatten out the load curve and improve the performance of all the units on the system.

STORAGE OF POWER

ONE METHOD of flattening out the load curve is to store some of the surplus off-peak power for use when it is needed during the peak loads.

Man has not yet devised a means of storing large quantities of electric power. There is a very simple means of storing hydraulic power. This is called pumped-storage hydroelectric power. If there is a stream, or a body of water near adjacent high ground that can be available for a storage lake, a site may be considered suitable for a pumped-storage plant.

The scheme is to pump the water up into the lake, at the higher elevation, using off-peak power. Then when the lake is full we can run the water back down again to drive a hydraulic turbine and generate power during peak loads. It also happens that off-peak power costs less than what power can be sold for during peak loads. This is what makes pumped storage economical and a sound investment.

Europeans have been using pumped-storage units made up of a separate centrifugal pump and a separate hydraulic turbine, both mounted on the same shaft, with a generator-motor mounted between them. The generator-motor generates power when driven by the turbine, and pumps water when driving the pump. Two hydraulic units are needed, possibly in conjunction with a fluid coupling or mechanical coupling. Thus, the pumped-storage unit may be expensive and space-consuming. Nevertheless, these units have proved to be very economical.

Allis-Chalmers developed a simpler and less expensive unit called a reversible pump–turbine. It consists of a single hydraulic machine coupled directly to a generator motor. It looks very much like a conventional hydraulic turbine. For pumping, the motor draws power from the system and drives the centrifugal pump, which pumps water from the lower level up into the storage lake. For generating power, the water flows down from the storage lake to drive the turbine and generator, and delivers power back to the system. For pumping, the unit runs in one direction; and for generating, in the reverse direction.

A special article recommended for publication by the AIEE Power Generation Committee.

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The pump–turbine has a spiral case, an impeller–runner, movable wicket gates controlled by a governor, an elbow draft tube, and a steel pit liner. In most cases, the most economical pump–turbines will be large units, with an output of at least 10,000 kw. Units can be built for outputs of 200,000 kw under certain head conditions. The head under which they can operate economically may be between 50 and 1,250 feet.

The company has built three units for the Sao Paulo Light Company of Brazil, each rated to generate 19,000 hp under 89 feet head, and for pumping 1,800 cfs (cubic feet per second) at 78 feet head. The first reversible pump–turbine installed in the United States was furnished by Allis-Chalmers for the Flatiron Power Plant in Colorado, for the Bureau of Reclamation. This unit is rated to generate 12,000 hp under 290 feet head, and to pump at heads from 200 to 300 feet. This is the first unit of its kind built to run at two different speeds for pumping and generating. The generator motor required a new design, in order to be run at 300 rpm for pumping and at 257 rpm for generating, both at 60 cycles in a synchronous machine.

The largest pump–turbine in the world was built for the Hiwassee Power Plant in North Carolina, for the Tennessee Valley Authority (TVA). This unit is capable of generating 120,000 hp at about 233 feet head, and is rated at 80,000 hp under 190 feet head. It can pump more than 4,600 cfs against 172 feet head, and is rated to pump 3,900 cfs against 205 feet head. The speed is 105.9 rpm in either direction. The motor is rated at 102,000 hp, and is the largest motor in the world. The impeller–runner is more than 22 feet diameter, which makes it the largest Francis type runner in the world.

This unit was described in an article by L. R. Sellers and J. E. Kirkland of the Tennessee Valley Authority (*Electrical Engineering*, Mar. 1956, pp. 263-69). Several other articles, written by other TVA engineers, have appeared in the trade journals.

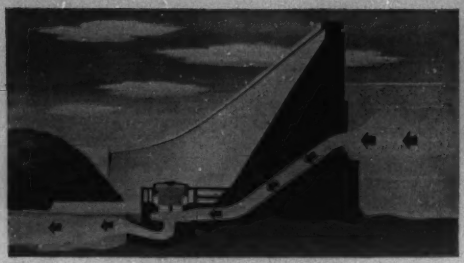
STARTING THE PUMP

To START such a large pump would require about 27,000 kw, with the wicket gates closed and fully primed. This would cause a high inrush of current from the system. This is reduced to about 2,000 kw, by blowing the water out of the runner so it can start up while rotating in air. The tail water level is about 15 feet above the bottom of the runner. The water inside the closed wicket gates is depressed to about 5 feet below the bottom of the runner. The operator presses a button in the control room, and compressed air at 100 psi rushes in through a pipe on the top cover plate of the unit. After about 1 minute, a volume of 3,700 cubic feet of water is pushed down and out the draft tube until the level drops to about 5 feet below the bottom of the runner. One of a pair of float switches on the draft tube at this elevation cuts off the compressed air, and a signal lamp goes on in the control room to tell the operator that the pump is ready for start-up.

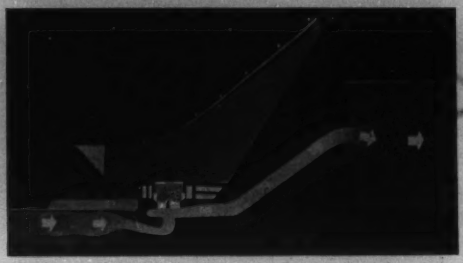
With the reduced load on the motor, it can now be started at one-half voltage and the inrush current is less than rated full-load current. The operator closes the starting circuit breaker and the pump–turbine begins to revolve. It takes a large motor such as this about 2 minutes to accelerate up to its rated speed at 105.9 rpm. At about 98% speed, sequence relays open the starting circuit breaker and, after about 1 second, close another circuit breaker called the running breaker. This connects the motor to the line at full voltage of 13,800 volts. The time interval is determined so the frequency of the motor which had been on one-half voltage falls into step with the system frequency at full voltage. Now the operator turns the controls on the board which send impulses to the governor and cause the wicket gates to open. There is a prescribed gate opening for about every 15 feet of head, for pumping, and the operator opens the gates to the proper gate opening. The head for pumping may vary from a minimum of about 170 feet with Hiwassee Lake drawn down to about 254 feet when the lake is full. The gate opening may vary from about 90% at the lowest head to about 50% at the highest head. By varying the gate opening, the pump always operates at its optimum efficiency. At the end of a pumping cycle, the operator works the controls on the board that cause the governor to close the wicket gates, and when they are closed the circuit breaker is opened and the motor is disconnected from the line. As the unit slows down and reaches about one-half speed air brakes are applied automatically to the motor rotor and the machine comes to a stop.

Installing the impeller–runner of the Hiwassee pump–turbine.

The rotating mass of the motor rotor, the 40-inch shaft, and the runner with its hydraulic thrust cause a downward load on the Kingsbury thrust bearing of almost 700 tons. To start this load from standstill, it is essential to have an oil film on the surface of the shoes of the thrust bearing to avoid damaging the babbitted surface of the shoes. High pressure oil at 1,000 psi is injected at the center of each shoe just before start-up. This film of oil, less than 0.002 inch thick, reduces the friction to such an extent that it would be possible for two men to turn this huge load by pulling on an arm of the rotor. The high pressure oil is also injected automatically during shutdown, when the speed drops to about one-half normal speed.



Changing water power to electricity. During the day, when homes and factories make their biggest demands for electricity, water cascades down the penstock, whirls through the spiral casing and sets the turbine spinning in one direction to generate power.



Changing electricity back to stored water power. At night, when power demands are low, electricity from other plants flows back to the generator–motor, which now turns the unit in the reverse direction to pump water back into the upper reservoir.

For turbine operation, the operator moves the controls on the board to cause the governor to open the wicket gates a small amount. The water rushes in from the penstock and starts the runner revolving. In about 2 to 3 minutes the speed comes up to about 103 rpm. Then the operator carefully manipulates the controls so it gradually creeps up to 105.9 rpm. When the frequency of the unit is just in step with the system frequency, the synchroscope is moving very slowly across the 12 o'clock position of its pointer. The operator can now close the main circuit breaker with the least disturbance to the system, and connects the unit to the line. Then he opens the wicket gates very gradually and the generator picks up load. The wicket gates are then opened to the full position and the generator supplies power to the system. To shut down the turbine, the wicket gates are gradually closed, and when they reach the opening for no-load speed, the circuit breaker is opened to take the unit off the line. Then the wicket gates are closed to zero and the rotating mass slows down and is brought to a stop by the air brakes on the generator, with the brakes applied automatically below one-half speed.

LOSS OF POWER

WHAT HAPPENS if the unit loses power to the motor when pumping? A current-failure relay sends an impulse to the governor, causing it to start closing the wicket gates. The time of gate closure from full open is about 25 seconds. First, the water column suddenly stops moving up the penstock. This occurs in about 4 seconds. Then the water column starts moving down the penstock and acts as a brake against the runner still turning in the pumping direction. In about 7 to 8 seconds, the rotating mass comes to a stop. The wicket gates are now partially closed and still moving in the closing direction. Then the rotating mass starts turning in the turbine direction. When the wicket gates reach the zero position, the unit may be revolving from zero to 25% of normal speed in the turbine direction. When the gates reach zero position, the brakes are applied automatically and bring the unit to a stop.

If power fails during a generating operation, a current failure relay causes the governor to start closing the wicket gates. The runner starts to accelerate above normal speed. In less than 10 seconds, it reaches its maximum overspeed, which varies according to the head existing at the time of the failure. The wicket gates continue to close to the zero position, and then the rotating mass gradually slows down. The brakes are applied automatically below one-half speed and bring the unit to a stop. The maximum overspeed under the highest head at Hiwassee will only produce an overspeed of about 155 rpm, or not more than 46% above normal speed. The entire unit is designed to run safely at this speed.

ADVANTAGES OF PUMP–TURBINES

PUMP–TURBINES, like conventional hydraulic turbines, are very useful in a power system. They can be started up in a very short time, about 3 to 5 minutes. A pump–turbine can be motored on the system for turbine operation as a synchronous condenser, and can then go on load in less than 1 minute.

If a steam turbine is started from standstill, it must be warmed up very gradually before full steam pressure can be applied. This may take several hours. The life of a pump–turbine is from 25 to 35% longer than that of the average steam turbine.

We have now reached the threshold of using nuclear power. When nuclear power stations are in use, they must be operated on a very high load factor, practically continuously around the clock. Pump–turbines will improve the load factor of nuclear power stations by supplying large blocks of off-peak load. They will also supply large blocks of very necessary peak power, which will take place of an equal amount of power that would have to be provided in additional thermal units.

The potential hydroelectric power of the United States is being gradually used up, so that in not too many years there will be no more new projects left. Pump–turbines can be applied in many locations not suitable for conventional hydraulic turbines, and they will supplement the depletion of conventional hydraulic power. Pump–turbines someday may supply us with as much power as conventional hydraulic turbines furnish today, and they may even surpass this total.

Use of Phase Space in Transient Stability Studies

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ASSOCIATE MEMBER AIEE

J. E. VAN NESS
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IN THE PAST FEW YEARS a great deal of interest has developed in the analysis of nonlinear systems. Much of this has been the result of the great strides taken in the field of control systems.

In general, the condition of a system at any instant of time can be described by giving the values of certain system variables at that instant. The number of variables required depends on the order of the equations used to describe the system. The system studied here will be described in terms of the power angle δ and its first and second derivatives with respect to time, v and g. These three variables can be used to describe a space, called the phase space, as shown in Fig. 1. The plane of the g and v axis can be thought of as being in the plane of the page, while the δ axis is perpendicular to the page.

The motion of the system under any operating condition can be described by a curve in this space, or the general operating characteristics of the system can be studied if sketches of trajectories or flow lines for all of the space of interest can be made. Stationary points representing stable operating points can exist only on the axis where g and v are zero.

The trajectories of the system are sketched to make use of topological methods which will give a qualitative picture of the system behavior. However, it is very difficult to sketch three-dimensional curves. Therefore, cross sections are taken through the space and the direction and curvature of the trajectories where they pass through these cross sections are indicated on the resulting plane. A group of these cross sections formed at regular intervals through the space being studied will give a picture of the motion of the system through that space. It should be emphasized that these sketches show the intersections of the trajectories with the plane chosen, not the projections of the trajectories on the plane. Many choices could be made as to the planes to use for the cross sections, but the planes formed by setting δ equal to a set of constants seem the most satisfactory.

The first step in sketching the trajectories is to transform the equation of the system into the form

$$\frac{dg}{dv} = f(g, v, \delta) \qquad (1)$$

This usually can be done without too much difficulty as long as the original equation does not contain t explicitly.

By substituting fixed values into equation 1 for δ, it is reduced to an equation with only two variables, g and v. The equation can then be used to sketch the behavior of the trajectories as they pass through the g-v plane having the chosen value of δ.

Since the condition of the system at any instant can be described completely by giving the values of g, v, and δ, any operating condition can be represented by a point in the phase space. If the question of interest is whether the system is stable or not with certain initial values, the answer can be given by describing those regions of space from which trajectories lead to a stable operating point and those from which they do not. The dividing surface between these regions will be referred to as the stability boundary surface.

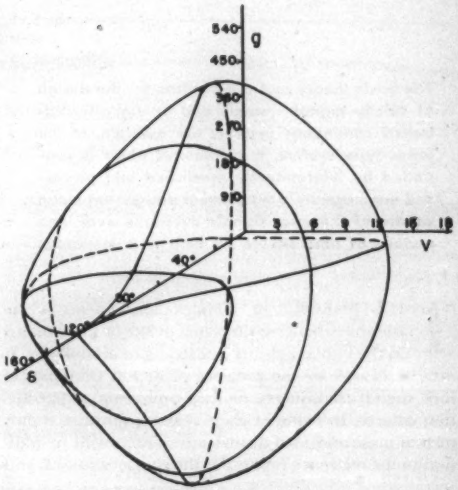

Fig. 1. Stability surface in phase space.

Thus far, no method has been discovered which will give this surface analytically. However, the surface can be found rather easily using an analog computer. The system is set up on the computer and then different initial conditions tested to see whether they lead to stable or unstable operation. By systematically choosing the conditions tried, the surface can be found without too much difficulty. The surface for the system studied is given in Fig. 1. Any points which lie within the surface will lead to a stable operating point, while those that are outside will be unstable. Therefore, in one sense, the relative stability of a system is indicated by the volume of space enclosed.

Digest of paper 58-83, recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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Statistical Design Theory for Sampled-Data Feedback Control Systems

S. S. L. CHANG
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The basic theory and a procedure for the design of strictly digital systems and of digitally controlled continuous systems are outlined. In the latter type system, a continuous plant is controlled by intermittently monitored and processed error signals. For optimum design, the mean square of the error signals averaged over long periods of time should be kept to a minimum.

THE THEORY of sampled-data systems is applicable whenever the signal at one or more points in the system appears as a sequence of numbers. It may be caused by the presence of digital transmission link, digital transducers, or data processing and reduction devices. In many of these systems, spurious inputs such as noise and load disturbances are present in addition to the reference input. For the spurious inputs, and sometimes for the reference input also, only statistical properties are known. It has been necessary to formulate a design procedure for a digital data-processing unit which receives its signal from the error-sensing device and applies the proper forcing signal to the controlled plant to give optimum system performance under aforementioned operating conditions. The word optimum will be further elaborated. One basic assumption is that all the inputs are generated from stationary random processes, so that the ergodic hypothesis is applicable. Although this assumption is too restrictive, it may be stipulated that in practice the only requirement need be that the change in the generating processes is negligible within a period a few times the system time constants.

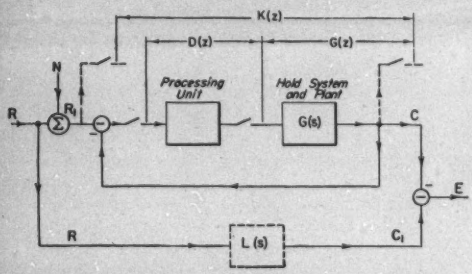

Fig. 1. Diagram defining system error *E*, which is to be minimized in the sense of least mean square amplitude.

THE OPTIMIZATION PROBLEM

FIG. 1 ILLUSTRATES the general design problem. The controlled variable C is to be as close as possible to C_1 which results from a given linear operation on R, such as time translation or prediction, integration, or differentiation, etc. However, in addition to the reference input, there is also noise N inseparably mixed with R. Furthermore, there is to be considered the fixed element or plant, which limits the response of the system in several ways. Among these are power limitation or saturation, transportation lag, and nonminimum phase. Another equivocating factor on system performance is that, in some applications, the system may have to make a decision on C with knowledge of $R + N$ only in the immediate past of a finite duration. Such systems will be referred to as systems with finite observation.

Because of the aforementioned factors, it is obvious that C cannot be made equal to C_1 no matter how the compensating elements in the servo system are designed. The mean square error criteria will be used as a basis for evaluating the relative merits of all possible systems. Two types of systems will be considered:

1. Strictly digital systems, in which the desired output is undefined except at the sampling instants. Consequently, such consideration as error between sampling instants is meaningless.
2. Digital controlled continuous systems, in which the over-all error at all times is to be minimized.

For a strictly digital system, it is required that

$$\lim_{N\to\infty} \frac{1}{N} \sum_{n=0}^{N} [c_1(nT) - c(nT)]^2 = \text{minimum} \qquad (1a)$$

For a digital controlled continuous system, it is required that

$$\lim_{T'\to\infty} \frac{1}{T'} \int_{0}^{T'} [c_1(t) - c(t)]^2 \, dt = \text{minimum} \qquad (1b)$$

Limitations due to the fixed plant can be expressed as follows:

Condensation of two papers: 57-1061, "Statistical Design Theory for Strictly Digital Sampled Data Systems," recommended by the AIEE Computing Devices Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill. Oct. 7-11, 1957, and published in AIEE *Communication and Electronics*, Jan. 1958, pp. 702-09; and 58-90, "Statistical Design Theory for Digital Controlled Continuous Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958, and scheduled for publication in AIEE *Applications and Industry*, 1958.

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Saturation

$$\overline{[v(t)]^2} < M \tag{2}$$

The overhead line indicates averaged value in the sense of either equation 1a or 1b, and $v(t)$ is a system variable in the controlled plant. The Laplace transform of $v(t)$ may be expressed as $V(s) = G_c(s)\, E_2^*(s)$, where $E_2^*(s)$ is the input to $G(s)$, and $G_c(s)$ represents the transfer function from $E_2^*(s)$ to $V(s)$.

Transportation Lag and Nonminimum Phase

Let m'' represent the transportation lag in sampling periods, and λ_i represent the zeroes of $G(z)$ outside the unit circle. The zeroes, λ_i, are grouped into a single factor $P(z)$

$$P(z) = \prod_{i=1}^{i=l} (1 - z/\lambda_i) \tag{3}$$

Let $m' = m'' + l$. $G(z)$ can be written as

$$G(z) = z^{-m'} P(z)\, G_1(z) \tag{4}$$

where $G_1(z)$ represents the balance of the transfer function. The constraint on system performance can be incorporated into the optimization problem by requiring that

$$K(z) = Z^{-m'} P(z)\, F(z) \tag{5}$$

where $K(z)$ is the closed-loop system function and $F(z)$ is an unknown function to be determined. All the poles of $F(z)$ are required to be inside the unit circle. In the following design procedure, it will be assumed that for the digital controlled continuous systems the spectral densities $\Phi_{rr}(j\omega)$, $\Phi_{nn}(j\omega)$, and $\Phi_{rn}(j\omega)$ are known. For a strictly digital system, the spectral densities may or may not be defined. Then the required data are $\Phi_{rr}(z)$, $\Phi_{nn}(z)$, and $\Phi_{rn}(z)$, which are defined as

$$\Phi_{i_3}(z) = \sum_{n=-\infty}^{n=\infty} \phi_{i_3}(n,T) z^{-n} \tag{6}$$

where $\phi_{12}(n,T)$ is $\overline{i_1(mT)\; i_2(mT+nT)}$ averaged either over m or over the statistical ensemble. The signals i_1 and i_2 may be both $r(t)$ or both $n(t)$ or one each.

OPTIMUM DESIGN PROCEDURE

THE OPTIMUM DESIGN PROCEDURE for a strictly digital system is very similar to that for a digital controlled continuous system. The two procedures follow, with the letters (a) and (b) to distinguish the two cases when necessary:†

1. Replace $j\omega$ by s in the spectral density functions $\Phi_{r_1r_1}(j\omega)$ and $\Phi_{r_1r}(j\omega)$ to obtain $\Phi_{r_1r_1}(s)$ and $\Phi_{r_1r}(s)$ respectively. (By definition: $\Phi_{r_1r_1}(j\omega) = \Phi_{rr}(j\omega) + \Phi_{rn}(j\omega) + \Phi_{nr}(j\omega) + \Phi_{nn}(j\omega)$, $\Phi_{r_1r}(j\omega) = \Phi_{rr}(j\omega) + \Phi_{nr}(j\omega)$.) Calculate the following z-transform functions:

(a) $G(z)$, $G_c(z)$, $\Phi_{r_1r_1}(z)$, and $\Phi_{r_1r}(z)$, and

(b) $G(z)$, $\hat{G}G(z)$, $\hat{G}_cG_c(z)$, $\Phi_{r_1r_1}(z)$, and $\hat{G}\, L\, \Phi_{r_1r}(z)$.

Here $GG(z)$, $G_cG_c(z)$ and $G\, L\, \Phi_{r_1r}(z)$ denote the z-transform functions of $G(-s)G(s)$, $G_c(-s)G_c(s)$ and $G(-s)\, L(s)\, \Phi_{r_1r}(s)$, respectively.

2. Determine $P(z)$ and m' from $G(z)$

3. Write as follows:

For case (a)

$$Y(z)\, Y(z^{-1}) = \frac{G(z)\, G(z^{-1}) + \eta\, G_c(z)\, G_c(z^{-1})}{G_1(z)\, G_1(z^{-1})} \tag{7a}$$

For case (b)

$$Y(z)\, Y(z^{-1}) = \frac{\hat{G}\, G(z) + \eta\, \hat{G}_cG_c(z)}{G_1(z)\, G_1(z^{-1})} \tag{7b}$$

where η is a positive constant to be determined by equation 2. Factorize $Y(z)\; Y(z^{-1})$ into $Y(z)$ and $Y(z^{-1})$. $Y(z)$ contains all critical frequencies inside the unit circle, while $Y(z^{-1})$ contains all the critical frequencies outside the unit circle. Similarly, factorize $\Phi_{r_1r_1}(z)$ into $R_1(z)$ and $R_1(z^{-1})$.

4. Define $Q(z)$ as follows:

For case (a)

$$Q(z) = \frac{z^{m-1}\, P(z^{-1})\, L(z)\, \Phi_{r_1r}(z)}{Y(z^{-1})\, R_1(z^{-1})}\,. \tag{8a}$$

For case (b)

$$Q(z) = \frac{z^{-1}\, \hat{G}\, L\, \Phi_{r_1r}(z)}{G_1(z^{-1})\, Y(z^{-1})\, R_1(z^{-1})} \tag{8b}$$

Expand the function $Q(z)$ into partial fraction expansion

$$Q(z) = \sum_i \frac{C_i}{z - \gamma_i} + \pi(z) \tag{9}$$

where the polynomial $\pi(z)$ may be a constant or zero. Collect terms with γ_i in and on the unit circle.

$$Q_s(z) = \sum_{\gamma_i \le 1} \frac{C_i}{z - \gamma_i} \tag{10}$$

5. The optimum closed loop system function is

$$K_0(z) = \frac{z^{-m'+1} P(z)\, Q_s(z)}{R_1(z)\, Y(z)} \tag{11}$$

6. The transfer function of the processing unit

$$D(z) = \frac{K_0(z)}{G(z)\, [1 - K_0(z)]} \tag{12}$$

SYSTEM WITH FINITE OBSERVATION TIME

WHEN THE OBSERVATION TIME is limited, the closed loop system function $K_0(z)$ is a polynomial of z^{-1}. The coefficients of the polynomial are obtained by solving simultaneous algebraic equations.

†To illustrate the parallelism of the two cases, the symbols as defined here are not exactly the same as the ones used in paper 57-1061.

Study of Return Losses on Loaded Trunk Cables

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TODAY'S forward-looking transmission objectives emphasize the need for adequate return loss on loaded trunk cables. This is especially true for those cables which are used as toll-circuit originating or terminating links. Because return loss is essentially a measure of uniformness of impedance, any irrgularity of inductance, capacitance, or resistance will reduce its value, thus limiting the usefulness of the trunk facility.

Statistical methods are frequently used to calculate the structural return loss which will be equaled or exceeded for any stated percentage of solid gage pairs within a cable sheath. This method requires that representative deviations of capacitance and inductance for cable and loading coils first be determined. Based on measurements of many samples, an inductance deviation of 0.007 for 88-millihenry loading coils used in the Bell System is generally assumed. A capacitance deviation of 0.027 per 6,000-foot loading section for exchange type trunk cable which has been placed without deviation test splicing or reel allocation may be expected. The inductance deviation from spacing of loading coils in the trunk plant varies widely and may be expected to range from 0.005 to 0.03 or more.

Methods of improvement consist largely of attempts to reduce irregularities. For working cables, this can be troublesome. In one metropolitan area, where 48% of all trunk cable pairs were found to be in the same sheath with exchange loops, this would be very difficult. Of course, loading coils may be easily spaced to reduce inductance deviation, and capacitance building out may be utilized for short sections. If building out is specified, it may also be desirable to provide additional resistance especially for the finer gage cable.

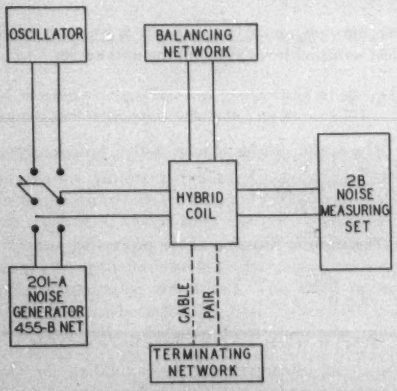

Fig. 1. Arrangement of test equipment for measuring echo return loss or return loss at single frequencies.

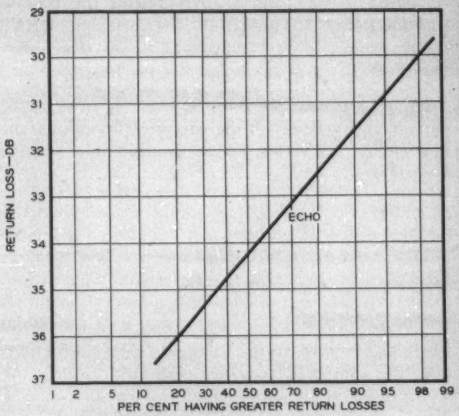

Fig. 2. Distribution of return losses.

When new trunk cables are being placed, actual measurements are easily obtained, which serve as a check of previous calculations and provide valuable acceptance test data. The return loss for working cables may also be measured, and although these measurements are somewhat more difficult to obtain, they are nonetheless valuable.

Fig. 1 shows a simple arrangement of test equipment whereby structural return loss may be measured at any frequency or for the echo band. The echo return loss is measured by using a Western Electric *201-A* noise generator equipped with a *455-B* network as a power source, and with a *2B* noise-measuring set, F1A weighting, as indicating instrument.

Fig. 2 shows the echo return loss distribution for a newly placed 19 gage trunk cable which was random spliced at about 750-foot intervals and loaded with four 88-millihenry coils spaced 6,000 feet apart with a 0.01 spacing deviation. This cable has good structural return loss, and shows that with proper engineering and acceptance tests loaded trunk cable can meet today's requirements.

Digest of paper 58-214, "Study of Return Losses on Loaded Trunk Cables and Methods Taken To Improve Them," recommended by the AIEE Wire Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Communication and Electronics*, 1958.

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Synchronous-Flux Generator

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A new type of generator is described, the output frequency, phase angle, and torque angle of which are independent of the shaft speed. The generator is automatically in synchronism with the system voltage, and the breakers can be opened and closed without any synchronizing equipment.

THE FLUX FIELD of an ordinary synchronous generator is made by the rotor current in the rotor circuit. The field is solidly tied to the rotor so that it moves as the rotor turns inside the stator. In an induction machine, the field is made by the stator and moves at the speed given by the frequency of the stator. It is not fixed with reference to the rotor. It is possible to have both the characteristics of a synchronous machine as far as ability to overexcite it is concerned, and the stability characteristics of an induction machine. This condition may be achieved by making the field with current in the rotor circuit but electrically tying its position to the stator frequency and phase with a feedback control system. In other words, one has a system for positioning the field inside the machine.

The synchronous-flux machine has a 3-phase stator identical to a conventional synchronous generator. The rotor may have nonsalient poles with two excitation windings 90 electrical degrees apart. Direct current in one winding will produce a set of poles which can be used to generate voltage in the conventional manner. If a small direct current is inserted in the other excitation winding, the two flux fields will add vectorially, and the resultant field will have a mechanical angle on the rotor somewhere between the two. By increasing the second excitation to a maximum, and decreasing the first to zero, the field can be moved 90 electrical degrees. Reversing the current in the first winding will permit a further motion of the resultant field from 90° to 180°.

If each winding is excited by a reversible d-c generator, a low-frequency 2-phase voltage on the exciter fields will produce an excitation rotating around the rotor of the synchronous-flux generator. If the 2-phase excitation is at slip frequency on a variable-speed generator, the flux slip speed on the rotor will add to the mechanical speed so that the flux is rotating at synchronous speed with reference to the stator. The phase of the generated voltage can be adjusted by changing the phase of the 2-phase slip-frequency excitation. A 20° excitation change will produce a 20° generated voltage change. The phase adjustment can therefore be used for automatic synchronization before the main generator is up to speed, or when it is over-speeding after a fault.

Fig. 1 shows the basic block diagram for obtaining a flux field which will rotate at exactly the speed and torque angle desired. The carrier frequency excites the single-phase rotor winding of the synchro transmitter. This rotates at the shaft speed, so that the stator windings pick up carrier voltages which vary sinusoidally with shaft position. These voltages go through zero and reverse phase each half revolution of the shaft, or approximately once each $\frac{1}{120}$ second. The transmitter output is a suppressed-carrier balanced modulation of a modulation frequency near 60 cps, corresponding to shaft speed. If the synchro transmitter has two 90° stator windings, the two outputs will have modulation envelopes 90° apart, forming a 2-phase 60-cps system, but the output carrier voltages are all either in phase or exactly out of phase with the carrier generator. This 2-phase modulation at shaft frequency is the measure of shaft speed. It is equally convenient to use a 3-winding stator on the synchro transmitter, in which case the output is 3-phase modulated single-phase carrier.

The speed signal excites the input of a synchro control transformer *A*, the shaft of which is turning at the desired flux speed in the main generator. If the machine is to be synchronized to a power system, then the reference speed is obtained from a small synchronous motor connected to the power system. The output of the synchro control transformer *A* has the difference speed, or slip speed modulation. The modulation phase is shifted by a second synchro control transformer *B*, which provides a convenient control on the internal torque angle of the main generator (between reference phase and open-circuit generated voltage).

The slip frequency is the correct value to be used in exciting the main generator to give a synchronous flux speed. The excitation is obtained from the slip modulation by a phase-sensitive rectifier for each synchro phase. This rectifier should deliver positive direct current if the synchro output is in phase with the carrier generator, and negative direct current if the synchro output is out of phase with the carrier generator.

Fig. 2 shows a simple rotary type of phase-sensitive rectifier or demodulator. The instant of maximum carrier voltage is shown. Terminal *1* of synchro phase *A* is connected to terminal *2* of the main generator rotor. Then 90° later, the carrier voltage goes through zero and the synchro outputs are all commutated, so that on the next half cycle, terminal *1* is connected to *3*. The rotor voltage from *2* and *3* is, therefore, d-c rectified

Condensation of a paper, "Synchronous-Flux Machine," which was awarded first prize in the San Francisco Section, AIEE Papers Contest. Recommended for publication by the Synchronous Machinery Subcommittee of the AIEE Rotating Machinery Committee.

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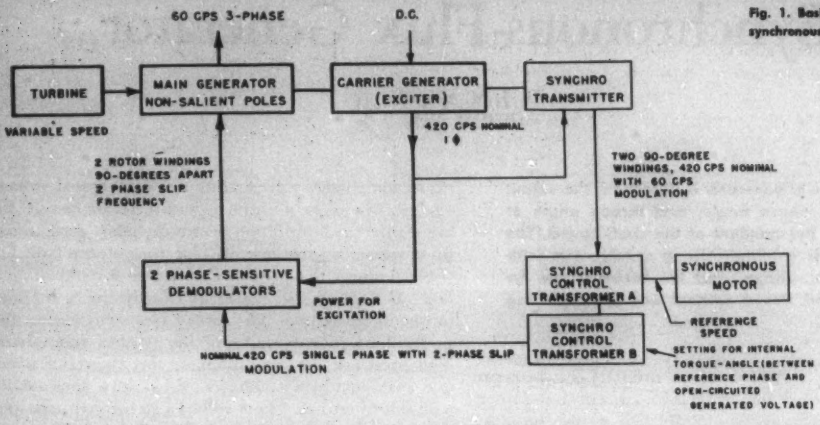
60 CPS 3-PHASE
D.C.
TURBINE
MAIN GENERATOR NON-SALIENT POLES
CARRIER GENERATOR (EXCITER)
SYNCHRO TRANSMITTER
VARIABLE SPEED
420 CPS NOMINAL
2 ROTOR WINDINGS 90-DEGREES APART 2 PHASE SLIP FREQUENCY
TWO 90-DEGREE WINDINGS, 420 CPS NOMINAL WITH 60 CPS MODULATION
2 PHASE-SENSITIVE DEMODULATORS
POWER FOR EXCITATION
SYNCHRO CONTROL TRANSFORMER A
SYNCHRONOUS MOTOR
REFERENCE SPEED
SYNCHRO CONTROL TRANSFORMER B
SETTING FOR INTERNAL TORQUE-ANGLE (BETWEEN REFERENCE PHASE AND OPEN-CIRCUITED GENERATED VOLTAGE)
NOMINAL 420 CPS SINGLE PHASE WITH 2-PHASE SLIP MODULATION

Fig. 1. Basic block diagram of synchronous-flux machine.

carrier, with a magnitude proportional to the voltage in phase *A*. In the other rotor winding, the d-c component is proportional to the voltage in phase *B*. If the carrier phase in the synchro phase *A* reverses, the direct current between *2* and *3* reverses.

EXPERIMENTAL TESTS

THIS FLUX-ANGLE CONTROL has been successfully applied to a 60-cps 14.5-kva generator delivering 11 kw at 0.76 power factor lagging, with a speed range of ±8%. This same machine operated continuously as a synchronous condenser at 14.5 kva, and as a variable-speed overexcited motor drawing capacitive current at 14.5 kva and delivering 15 hp. The machine was of conventional wound-rotor construction, and had almost 400% synchronous reactance. With only 100% excitation, it would operate stably as either motor or generator up to torque angles of almost 180°.

The 14.5-kva machine used a hard-tube amplifier type of phase-sensitive demodulator, such as those shown in Fig. 3. The vacuum tubes are used as switches to rectify the carrier voltage, so that the output power comes from the carrier generator and not from the synchros. When phase *A* is instantaneously positive, tubes *1* and *2* are conducting, and terminal *3* is connected to terminal *4*, so that the latter has the same polarity as terminal *3*. When phase *A* is instantaneously negative, tubes *5* and *6* are conducting, and terminal *7* is now connected to terminal *4*. Terminal *4*, therefore, has rectified direct current, which is positive if phase *A* is in phase with the voltage on terminal *3*, and negative if phase *A* is in phase with the voltage on terminal *7*.

The 14.5-kva machine rotor required 30 amperes (between two terminals of a 3-phase rotor) for 100% excitation, and required 120 amperes when delivering full kva at full power. The exciter wiring diagram is shown in Fig. 4. The 3-phase rotor was excited by two d-c generators in open delta. The d-c generators were aircraft units rated 28 volts, 150 amperes, and operated quite satisfactorily up to 5 cps. The pilot exciters were amplidynes, each with two control windings. The phase-sensitive demodulators delivered 10 milliamperes at slip frequency, and the other control windings were used for rotor-current feedback. The control loop encompassed the inductive lags of both the exciter field and the main rotor windings, and therefore automatically adjusted the exciter voltage to cause the rotor slip frequency currents to be in phase with the synchro slip frequency voltages.

The synchro control transformer *B* required only 0.1 inch-ounce of torque to change the a-c power from 11 kw generator action to zero or to 11 kw motor action, in a small fraction of a second. When the angle setting on the synchro control transformer *B* was suddenly changed, the electric power in the main generator windings changed instantly in a corresponding manner, roughly proportional to the sine of the torque angle. The change in power came from the inertia of the rotor, and the resulting rotor acceleration eventually resulted in a speed change, dependent upon the characteristics of the prime mover and its governor. In these tests, the speed deviations were limited to 8% of the synchronous speed, which corresponded to maximum slip frequencies of approximately 5 cps.

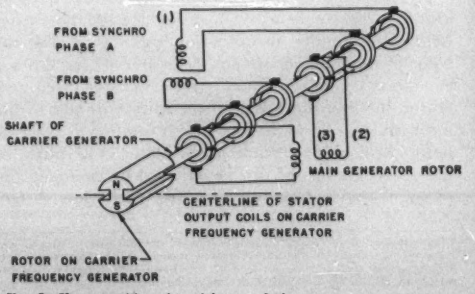

Fig. 2. Phase-sensitive demodulators of the rotary commutator type.

FAULT TRANSIENTS

A CONVENTIONAL GENERATOR delivering power through a long transmission line to a power system can have transient instability. When the circuit breakers open, the generator speeds up. When the circuit breakers reclose, all of the extra energy stored in the rotor has to be delivered back to the power system in the first half cycle of oscillation. The rotor rocks ahead, and even after the circuit breaker is reclosed it continues to increase its torque angle. If it stays within the stability angle for its peak swing, the generator will not fall out of step. Unfortunately, it is a two-energy storage system which will oscillate.

The synchronous flux generator does not oscillate when transiently disturbed. At any torque angle setting, the line breakers can be opened up with no shaft oscillations. The shaft speeds up in accordance with the prime mover governor setting and the shaft inertia, but the generator terminal voltage remains in synchronism with the power system. At any time during this speed transient, the line breakers may be reclosed, again with no shaft oscillations. The power delivered immediately returns to the same value of power delivered before the line breakers were opened, and the shaft speed begins to slow down, and will eventually reach the same value which it had before the breakers were opened.

From the power system viewpoint, the machine appears to have an infinite moment of inertia, because the generator terminal voltage does not change in phase after the breakers are opened. The energy delivered to the rotor during fault conditions remains in the rotor as increased speed, until the governor restores the desired speed setting. This eliminates the necessity for fast reclosing because of transient swing considerations.

ROTOR POWER CONSIDERATIONS

WHEN THE SHAFT SPEED is less than the synchronous speed, and the flux must rotate at the synchronous speed in the air gap, then the relative speed of the flux on the surface of the rotor is the difference speed, or the slip speed. The flux runs around on the rotor in the same direction as the rotation. The rotor windings produce this difference speed with the multiphase slip-frequency currents. When the shaft speed is more than the synchronous speed, then the flux must rotate backwards on the rotor, relative to the direction of mechanical rotation. The phase sequence of the slip-frequency rotor currents is reversed from the previous case.

The rotor voltage is the sum of two components, the resistive and the reactive drops. The latter can be considered to be the voltage generated in the rotor windings by the slowly rotating flux field. The resistive drop is essentially equal to the direct voltage that would normally have to be provided for excitation. One component of the excitation power is this d-c or resistive component. For large speed deviations, there is an additional power component that must be considered. The product of the voltage generated by the rotating flux field and the current in the rotor windings gives a slip-

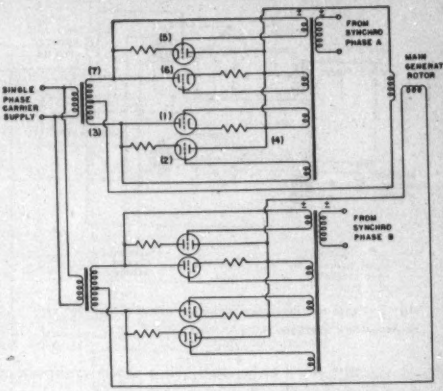

Fig. 3. Two phase-sensitive demodulators using high-vacuum tubes in full-wave connection, for rotor supply of synchronous-flux machine.

frequency power component that is greater than the resistive losses. The excess power required from the excitation circuit is equal to the per-unit slip times the delivered stator power. When the speed is below synchronous, and the machine is operating as a generator, this power must be supplied by the exciters as, for example, the d-c generators in Fig. 4. When the generator shaft speed is above synchronous speed, the exciters will receive power from the rotor, and will deliver this power back to their shafts and to their prime movers. This is a steady constant power summed over all the rotor phases, but it is pulsating at slip frequency in any one rotor phase. For this reason, it is desirable to have all of the exciters in Fig. 4 on a common shaft, so that the exciter prime mover sees only a steady power flow, and there are no slip-frequency components in the speed or torque of the exciter prime mover shaft.

It is possible to operate the main generator at a speed above synchronous, so chosen that the velocity component of slip frequency power just balances the resistive excitation losses. The exciter prime mover shaft would have zero torque, and could be replaced by a flywheel. The shaft between the two exciters for the two rotor

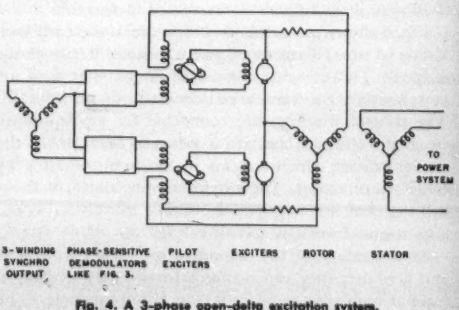

Fig. 4. A 3-phase open-delta excitation system.

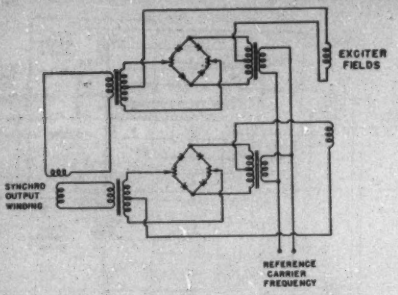

Fig. 5. Phase-sensitive demodulators using diodes for synchronous-flux machine.

phases would have a large oscillating power component at slip frequency, but there would be nothing else on this shaft except a flywheel. It is important to note that this "floating-exciter" condition corresponds to only one main generator shaft speed, and this is above synchronous speed, so that a small low-frequency current must be flowing in the rotor windings.

The exciter can be driven from a separate prime mover. For generator speeds below synchronism, the exciter prime mover supplies power to the electric circuit. For generator speeds above synchronism, the exciter operates as a motor, and delivers power to its shaft. The exciter prime mover must conserve this power in some manner, as for example, operating as a pump. The exciter is directly connected to the turbine shaft in Fig. 1 so that when operating above synchronous speed, the power delivered by the exciter to its shaft is directly available to the generator. The exciter power rating must equal the generator per-unit speed deviation from synchronous speed times the generator power.

PHASE-SENSITIVE DEMODULATORS

THERE ARE OTHER TYPES of demodulators that can be used in this application. Fig. 5 is a diode ring demodulator, common in communications work. It is inefficient and, therefore, should be used only at low power followed by the main exciter. The reference carrier is the control that switches the right two diodes on if the upper reference lead is positive, or switches the left two diodes on if the upper reference lead is negative.

Fig. 6 shows phase-sensitive demodulators, each consisting of two self-saturated magnetic amplifiers with d-c outputs. The currents are added in parallel with reversed polarity to form a zero-center push–pull output. The control windings are connected for a-c inputs instead of d-c inputs, and are in series to balance out the carrier voltage which appears in the input winding by transformer action. The carrier supply always delivers full kva, but it changes from reactive to resistive as the output goes from zero to full voltage.

An advantage of the demodulators shown in Figs. 3 and 6 is that they can be built for directly exciting a rotor at high power and very large slip frequencies. The system shown in Fig. 4 is ideal for stationary power plants, but has the disadvantage that the exciter limits the maximum slip frequency.

The maximum allowable variation of generator shaft speed will determine the frequency variation of the "carrier generator" and so imposes design limits on the demodulators, which must operate correctly over the full range of frequency variation.

POWER STATION CONTROL

FIG. 7 is a proposed diagram for automatically reclosing a stationary generator after a fault. The frequency of the power system and the phase of the terminal voltage of the machine is "remembered" by the flywheel on the synchronous motor which provides the reference-speed shaft for the reference synchro. During the fault conditions, the generator speeds up, and the negative slip frequency rotates the excitation flux backwards around the rotor, keeping the identical excitation phase with respect to the flywheel. After reclosing, the generator will deliver the same power as before the fault. If the generator has not been delivering full power, and it is desired to reclose at full power to compensate for the possible loss of other capacity, the torque angle setting angle can be latched up to the maximum value permissible by the fault relays.

If one of several parallel long lines is lost, the line impedance after the fault will be greater, and with the same excitation angle, the generator will initially deliver less power, inversely proportional to the line plus machine impedance. The phase of the generator terminal voltage will be farther advanced ahead of the remote infinite bus than before the fault. The reference synchronous motor will begin to advance in phase, with a time constant proportional to the flywheel inertia, and

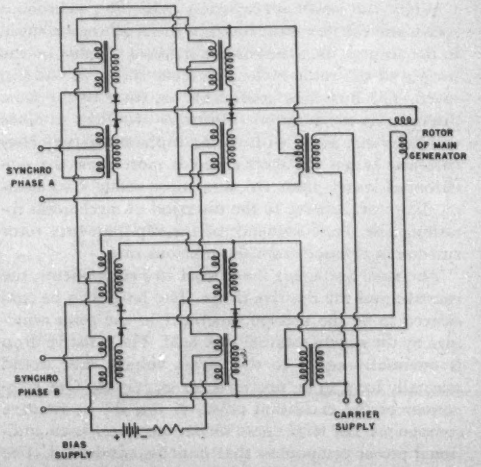

Fig. 6. Self-saturated magnetic amplifier phase-sensitive demodulators, with rotor power from carrier supply.

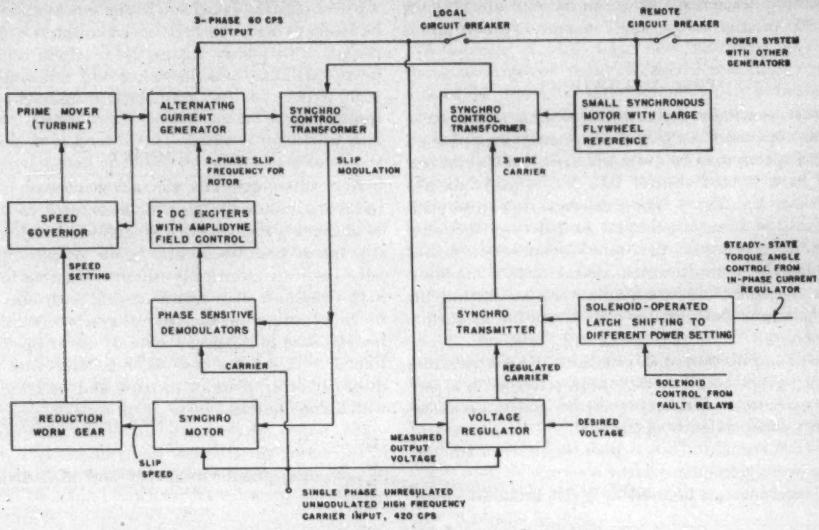

Fig. 7. Synchronous-flux generator with automatic reclosing at a predetermined maximum torque-angle setting. Power is controlled by steady-state torque-angle setting.

inversely proportional to the motor torque-angle constant. The steady-state condition is reached when the main generator is again delivering a power corresponding to the setting on the torque-angle control. The transient time can be adjusted by selecting the flywheel size, or by controlling the excitation in the reference synchronous motor.

If the reference synchronous motor is left connected to the main generator terminals before reclosure after a fault, it will tend to advance in phase to the open-circuit voltage phase. If the reference synchronous motor is disconnected, or if its excitation is completely removed in the period before reclosure after a fault, the flywheel will tend to slow down. There is a particular value of reduced excitation for the reference motor for which its speed and phase will remain relatively constant. This value should be used for the interval before reclosure after a fault.

The flywheel transient after reclosure can be isolated from the generator power flow after reclosure by using an in-phase current regulator to control the setting of the torque angle synchro. During open-circuit conditions, this regulator would be inactive, and the torque-angle setting would be arbitrarily determined from known power-flow characteristics for the various transmission-line configurations. Information concerning the number of operating transmission lines and their impedances would be related to the control, and it would select a torque angle such that the initial current following reclosure would be full-load current. Immediately thereafter, the in-phase current regulator would be energized, to prevent any further changes.

After recovery from a fault, the shaft speed is too fast, and a synchro motor connected to the slip-modulated carrier system would rotate at slip speed. The rotation of this shaft could be used to change the governor setting and reduce the turbine power until the speed reached synchronism again. Since the position of the slip speed shaft controls the governor, the slip will be brought to zero.

If transient stability is the only reason for using the synchronous-flux machine, it might be desirable to make one excitation winding heavy, which would normally be excited, and the other one a short-time-rating winding which would only be used during fault conditions.

The possible operational advantages of a machine of this sort are:

1. It could be started and be delivering power to the line faster. Both turbine torque and induction motor torque could be available for bringing it up to speed, by using starting resistors in the rotor circuit.
2. It is automatically synchronized. The rotor could be excited and power delivered before it is up to full speed.
3. It would be stable and could not fall out of step during transients.
4. A standby running at full speed but no power could instantly deliver full power by changing the torque-angle control, before the turbine governor opens up the throttle.

Constructionally, the machine could be smaller because it does not need to have as much inertia to satisfy

stability requirements, and it can operate much closer to the 90° internal torque angle maximum power point.

OTHER APPLICATIONS

SEVERAL SYNCHRONOUS-FLUX GENERATORS can be paralleled and operated at the same frequency, even though the shaft speeds may be quite different. Each generator would have a load control like the synchro control transformer *B* in Fig. 1. These can be automatically adjusted so that there is an equal load division between the various generators. This type of connection would be applicable to multiengine aircraft power supplies. In this case, the rotor windings would be identical in each phase, and designed for continuous low-frequency excitation.

Another application of this machine is for a variable-frequency generator. The flux-speed reference is a precision oscillator, which controls the generator stator frequency independently of the shaft speed. This is not a frequency regulator, but a phase-angle regulator, so that the average frequency error is zero.

This machine can be used as a synchronous motor. By inverting the operation of the synchro system, it can be made to keep the shaft speed constant, regardless of the stator frequency. Again, the precision reference can be an oscillator, and the motor will run synchronously with respect to the oscillator, for different oscillator frequencies.

SUMMARY

A SYNCHRONOUS-FLUX GENERATOR constructed like an induction motor has been demonstrated to be capable of delivering lagging current stably through a range of slip speeds both above and below synchronism. It has been instantly electrically switched from no load to full load without a shaft transient, and with only 0.1 inch-ounce of torque on the control synchro. While delivering full load to a power system, it was tripped from the line and reclosed a few seconds later with no shaft transient other than an increase and decrease in speed with no oscillations.

It is hoped that this type of control will prove useful in increasing the stability limits of power systems, and in providing precise frequency and load division controls.

Static Electricity in the Petroleum Industry

J. C. HOWARD
MEMBER AIEE

Many fires of unknown origin can justifiably be traced to static electricity. Increased knowledge has improved protection but the still unsolved static problems have assumed serious proportions because of the much broader explosive range of jet fuels compared with gasoline.

STATIC ELECTRICITY is a phenomenon that, by its very nature, is surrounded with an element of mystery. However, it is simply electricity generated in an unfamiliar manner that is usually obscured by environment. Static electricity is generated in most everyday activities but is never noticed unless the intensity is sufficient to cause a spark or shock. The apparent simplicity of generation belies the complexity of the phenomena.

An electrified body is said to be a body that exhibits property of charge. A charge is not a material particle as some times pictured, but a tension or force—a mysterious "something." It is that condition which creates an electric field and may be the property of any kind of material. Charge always consists of two equal and opposite charges and, as Faraday has established, there is no absolute charge.

Static electricity simply is electricity that results from charge, as does all electricity in the final analysis. Charge can be developed in a number of different ways. In the generation of static electricity, charge originates from an unbalanced state of matter of atomic and molecular proportions. This unbalanced state of the electrical forces in matter may exist in several forms: electronic, atomic, or dipolar types of polarization. Although it can occur in response to an applied field, it can also be developed by physical operations on dielectric materials thus creating a condition of charge that is called static electricity.

GENERAL ASPECTS OF STATIC GENERATION

ELECTRIFICATION OF A BODY may be accomplished (1) by friction between two bodies followed by their separation, (2) by induction, where a conductor is brought

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into the field of an electrified body, and (3) by polarization, where a nonconductor is brought into the field of an electrified body. The petroleum industry is concerned principally with processes involving primal generation similar to that in the first method.

Just what occurs in the primal generation of charge is unknown. It is known that charge is quantized and that the electric field applying to macroscopic matter is a result of quantum fields. This belongs within a field of theoretical physics known as quantum electrodynamics. For practical purposes, it is sufficient to say that static is generated by friction, induction, or any one of a number of other physical operations.

Dr. W. Heisenberg has stated that constructing a theory is a process applied not only to the results of scientific experiment, but, in the course of ages, also to the simplest experiences of daily life, and in this way all concepts have been formed. It is further said to be advisable to introduce a great wealth of concepts into a physical theory, without attempting to justify them rigorously, and then by experiment to decide at what points a revision is necessary. Most theories of the phenomena of static electricity have leaned heavily on this philosophy.

GENERATION BY FLOW AND AGITATION

STATIC ELECTRICITY PROBLEMS peculiar to the petroleum industry are encountered in the manufacture and handling of dry, refined oils such as kerosene, gasoline, jet fuels, and similar hydrocarbons. These products are excellent liquid dielectrics capable of producing charge during flow or agitation and the hazard of static electricity in their presence is quite obvious.

S. S. Mackeown and V. Wouk found that during the filling of tank trucks with gasoline, the production of charge is directly proportional to the velocity and the total charge produced is independent of the velocity. The rate of production of charge was found to be approximately inversely proportional to the cross-section of the fill pipe.

A number of ideas have been advanced to explain the generation of static electricity resulting from the flow of oil through a pipe. As previously indicated, the phenomena is difficult to explain by electrokinetic theory or other theories dealing with macroscopic matter. Ordinary gasoline is said to contain at least 100 known hydrocarbons and the total number of hydrocarbons in some gasoline may run as high as 500. Certain hydrocarbons or combinations of hydrocarbons may be responsible for the generation of charge and some investigation has been made in this direction. Again the complexity of the problem is evident.

Most experimenters have found that some impurities in oil improved the generation of charge. A small amount of water in the oil is particularly valuable in this respect. Early experimenters found that no residual discharge will take place if a dielectric is perfectly homogeneous, and that impurities in fluids and oils lead to the residual discharge (Sir James Jeans "Electricity and Magnetism"). This circumstance may have some bearing on the problem with respect to the relaxation of charge in oils.

FILLING TANKS INSULATED FROM GROUND

THE FACT THAT OIL BECOMES CHARGED by flow through a pipe or hose leads to the possibility of charging the body of a tank during the time the tank is being filled. A metallic tank insulated from earth may be considered as a Faraday "ice pail." A characteristic of Faraday's "ice pail" or other hollow metallic body insulated from earth, is its ability to accept any available charge, irrespective of its own voltage. This is a principle used in the Van de Graaff generator.

The word "tank" is used categorically and it may represent a tank truck, automobile, tank ship, barge, or even a five-gallon can. The loading of a tank truck is a typical operation that requires protection against static (Fig. 1). The truck is well insulated from earth by its rubber tires and accumulates a charge when charged oil from the loading line enters the tank. If the rate of charge exceeds the rate of leakage over the tires, it is possible for the potential of the truck to reach several thousand volts with respect to ground. If a discharge path in the form of a spark gap presents itself, particularly near the loading dome where the fill pipe enters, there is a good possibility of igniting the air-vapor mixture.

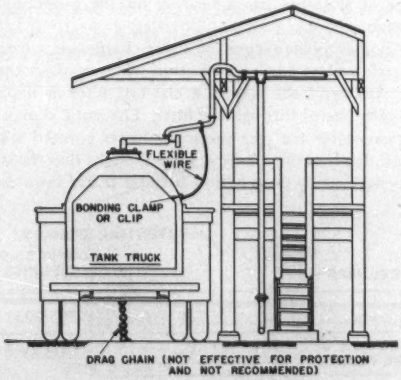


Fig. 1. Tank truck loading.

The capacitance of a typical truck with respect to ground will run about 1,000 micro-microfarads. A typical charging rate may be of the order of 6 times 10^{-8} amperes. Inasmuch as potential is the ratio of charge to capacitance, the truck could reach a potential of 3,000 to 4,000 volts in one minute of filling.

The stored energy may be found by the equation

$$W = (1/2) \quad (CV^2) \qquad (1)$$

The minimum spark energy ranges from 0.2 to 0.3

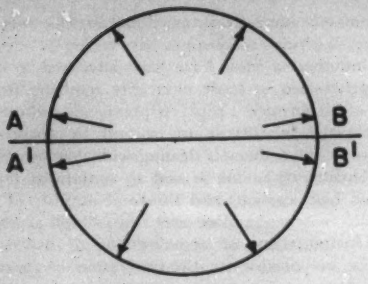


Fig. 2. Capacitor analogy.

millijoules for the ignition of hydrocarbons according to the United States Bureau of Mines.

The method of protection for a tank insulated from ground is to ground the tank. This applies equally well to all types of metallic tanks and containers that would be normally insulated from ground. Tankers and barges are inherently grounded and do not accumulate a static charge.

Theoretically, all tanks should be grounded during filling but practically this is not the case. Tank trucks are always grounded during loading because of the high rate of charge resulting from a high rate of oil flow. Experience has taught, in the filling of automobiles where rates of flow are low, that the rates of charge and leakage are such that dangerous charges do not accumulate and grounding is not necessary. Small containers exceptionally well insulated from ground have been known to accumulate a charge even at low rates of fill. Except in the case of automobiles where there is a record of safe experience, all types of containers should be grounded or bonded to the container or pipe supplying the liquid, provided the latter are grounded.

Grounding is the means of discharging any ungrounded metallic object that can become charged. Whether this is done by conecting directly to ground or by "bonding" to an object already grounded makes no difference. If an ungrounded charged metallic object is "bonded" to a second metallic object that is ungrounded and uncharged, it will share the charge of the first object. If the second object is quite large as compared to the first object, the charge will become so widely dispersed that it will, in effect, disappear. In common practice, the second object is usually the earth because it is a very large object and is usually convenient for connection. However, the second object could just as well be any large uncharged metallic object even though insulated from earth. A good small-scale example is the discharge of static from the human body inside of an automobile, where the automobile is insulated from the earth by its tires. Large metallic bodies would be needed to disperse the charges developed at high rates of generation. The principles involved are simply those of the inverse square law and the law that potential is the ratio of charge to capacitance. Ground resistance is the resistance encountered in making connection to the earth. Low resistance is not required for static drainage but the connections should possess adequate mechanical strength. Storage tanks resting on the earth are sufficiently grounded.

STATIC CHARGES ON FREE OIL SURFACES

A STATIC CHARGE of major proportions may appear over the free oil surface when dry, refined oil is pumped into a cone roof storage tank, irrespective of tank grounding. The potential gradient can be sufficient to produce sparks at the oil surface and a number of disastrous fires and explosions have been attributed to this phenomenon. High intensity charge on the free oil surface is probably much more prevalent than the number of fires indicate because the air-vapor mixture at the free oil surface is usually too rich to ignite.

The charge on the free oil surface appears to originate from the flow of oil into the tank and possibly agitation of the contents of the tank. It has been observed that the area of the oil surface bears a relation to the degree of surface charge. It has been thought by some that tanks 15 feet or less in diameter do not produce dangerous charges. However, little study has been made of the relation of charge to surface area.

A surface static phenomena has also been observed in the treating of naphthas in air-blown agitators. In this process, air is blown through the liquid to provide agitation for mixing chemicals or water with the naphtha. Static sparks have been seen to dart about on the surface of the naphtha during the settling period following agitation with chemicals and with water. The charge on the oil surface of an agitator appears to originate from the settling of water or chemical solution through the volume of oil. There is little evidence of static during the period of agitation. During the filling of an "agitator" with naphtha at a rate sufficient to make the surface boil and froth, no sparks or evidence of dangerous charge is observed. This raises the interesting possibility that violent surface agitation may, in some way, mitigate the surface charges, or, that the type of agitation has a bearing on the generation of charge.

Another phenomenon of static charge on a free dielectric surface has been observed when sparks occur on the surface of the clay in a clay-bed filter as naphtha is being passed through the filter. The static charge disappears after the clay surface becomes covered with a small depth of oil. There is some thought that the static is generated by evaporation because it has been estab-

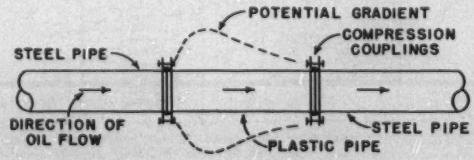


Fig. 3. Potential at section of nonconducting pipe.

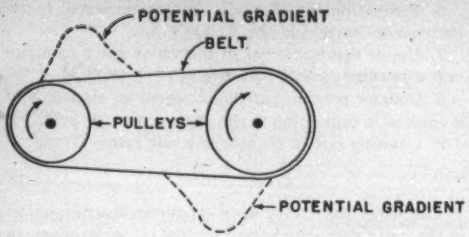


Fig. 4. Potential gradient on a belt of nonconduction material.

lished that static can be generated by rapid evaporation and experimentally demonstrated by boiling hydrocarbons.

From experience with static charges on free oil surfaces, a pattern of conditions favorable to static generation may be developed as follows:

1. Generation appears to be restricted to refined oils of good dielectric strength.
2. Water in the oil enhances generation.
3. Generation is always associated with some form of motion of the oil.
4. Large oil surfaces are more susceptible to generation than small surfaces.
5. Explosions in tanks during filling usually occur shortly after filling begins and with only a few feet of oil in the tank.

Some questions naturally follow the foregoing recitation on observed phenomena. How does the surface of the oil become charged? What can be done about it? At present, the industry is attempting to find an answer to both of these important questions. Some conception of the problem may be developed from the stated observations and from other static phenomena closely related to that produced by the flow of oil.

It has been established that oil flowing in a pipe will become charged. How the oil becomes charged is problematical, and it is not necessary to know this to construct a picture of the problem. A metallic pipe with oil flowing through it might be looked upon as a two plate capacitor with plates AB and A′B′ (Fig. 2) connected together with the oil forming the dielectric. Carrying this conception further, the wall of the pipe could be considered to contain an infinite number of plates all connected together. The potential approaches zero and the interface between the oil and the pipe becomes an equipotential surface because the plates are all short circuited. There are no lines of force outside this equipotential surface and all lines of force which originate on the charges imprisoned in the dielectric and which do not terminate on similar charges must terminate on the surface of the dielectric. The condition might be considered to represent infinite capacitance because capacitance is the ratio of charge to potential and the potential approaches zero. If a section of the metal pipe were suddenly removed hypothetically, the capacitance would become very small and the potential would rise to high values. This takes place when oil enters a storage tank and, because all oil-to-tank contact surfaces are equipotential, the charge can only display itself at the free oil surface.

The action described is supported by the following observations:

1. Measurements show that the potential of a stream of oil is highest at its point of exit from a metallic pipe.
2. A high potential will appear on a section of plastic pipe inserted in a run of steel pipe carrying charged oil (Fig. 3). The gradient is highest near the point of exit from the steel pipe and decreases in the direction of flow. This phenomenon has been observed to reach sparking intensity at the surface of a nonconducting pipe.

The action of charged oil flowing in a pipe in analogous also to the generation of charge in the operation of a belt over pulleys (Fig. 4). In this instance, the charge is generated at the pulley where the capacitance is high. As the elements of the belt leave the pulley, there is a sudden and high rise in potential as these elements encounter increasingly lower capacitance. The potential decreases in the direction of belt travel similar to the decrease observed in the direction of oil flow in the nonconducting section of pipe.

Most explosions in tanks attributed to static electricity, have occurred within a short time after filling

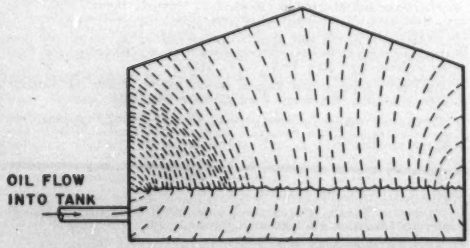


Fig. 5. Electric field in a tank being filled at low oil level.

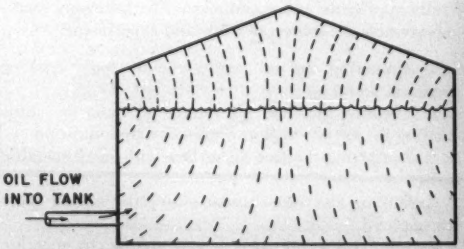


Fig. 6. Electric field in a tank being filled at high oil level.

started and when the level of oil in the tank was low. This is what might be expected because the field parallel to the oil's surface would be more intense under conditions of low-oil level and, furthermore, the point of entrance of oil into the tank would be closer to the surface of the oil. The resulting asymmetrical distribution of field would introduce a high-potential gradient at the surface of the oil near the point of entrance (Fig. 5). As the level of oil rises, approaching closer to the roof, the distribution of surface charge becomes more uniform and the likelihood of spark discharge will decrease (Fig. 6).

The concepts of the problem as just presented suggest a possible method of dissipating the electrostatic energy stored in the oil by decreasing the capacitance, with an attendant rise in potential, at a safe location adjacent to, and outside of the storage tank. The decrease in capacitance may be accomplished by use of a section of pipe made of insulating material inserted in the filling line to the tank. External to, and surrounding the pipe of insulating material, would be a number of sharp conducting points to remove charge to ground. Introducing an auxiliary tank in the line or enlarging a section of the filling line before it enters the storage tank would decrease the capacitance and provide a potential rise that would likewise dissipate the charge by increased leakage in the liquid. The effect is to raise the potential to increase leakage as contrasted with methods wherein leakage of charge is obtained by increasing the conductivity of the oil.

CHARGES ON A FREE OIL SURFACE

THE PROBLEM OF PROTECTING AGAINST CHARGES on a free oil surface resolves itself into (1) preventing or reducing charge generation, (2) dissipating the charge, or (3) eliminating or reducing the free oil surface.

If a free oil surface does not exist then there can be no hazard. The free oil surface can be eliminated by the use of the floating roof tank, a type of tank originally designed to reduce loss of volatile flammable liquids. The floating roof tank has now been pressed into service as the only sure method of combatting the static hazard on a free oil surface. The use of floating roofs for static protection is rather limited as they are applicable only to fixed storage and cannot be applied to mobile tanks.

The ideal type of protection must be one that is generally applicable and economical. The following methods are now the subject of study and experiment:

1. Rendering the oil conductive by some type of chemical additive.
2. Exposing the free oil surface to radiation, thus making the surface region conductive by ionization.
3. Blanketing the free oil surface with small metallic balls.
4. Making the vapor space above the oil an inert atmosphere.
5. Subdividing the surface and volume by metallic egg-crate construction.
6. Dissipating the charge by means favorable to relaxation of charge.
7. Use of flammable gas in the vapor space to maintain a mixture too rich to ignite.
8. Counter potential methods, where an electric field is applied in opposition to the static generated field.
9. Limiting rate of oil flow to a safe rate.

CONCLUSIONS

THE IDEAS THAT HAVE BEEN SUGGESTED for mitigation of the static electricity hazard on free oil surfaces are, in general, not new ideas. Few of these ideas have been pursued to any great extent and their value remains to be established. It must be recognized that in working on a problem of this type, a wealth of ideas are necessary before discovering one that will prove to be a safe and economical solution.

Several oil companies have devoted much time and expense to the problem and have made valuable contributions to the literature on the subject. The American Petroleum Institute (API) publication *RP 2003*, "Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents," describes very well the various static hazards and known methods of protection.

The phenomenon of charge generated by flow, and the volume and surface charge in a tank, are presently the subject of research sponsored by the API, at Johns Hopkins University and the Massachusetts Institute of Technology respectively.

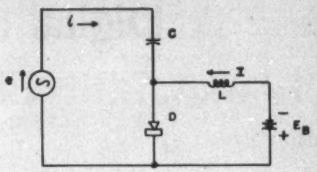
The complete elimination of static electricity may be a difficult goal to attain. However, the work in progress holds much promise of not only mitigating the hazards of static electricity but also contributing something to our knowledge of the nature of matter.

REFERENCES

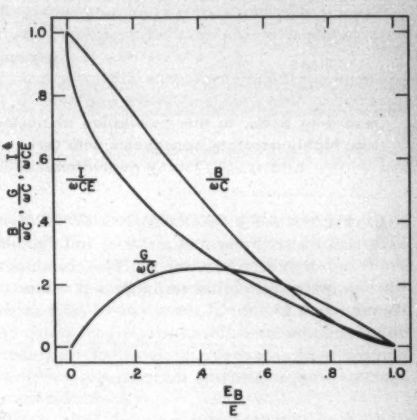
1. Electric and Magnetic Fields (book), S. A. Attwood. John Wiley & Sons, Inc., New York, N. Y., 1941.
2. Principle of Electricity and Electromagnetism (book), G. P. Harnwell. McGraw-Hill Publishing Company, Inc., New York, N. Y., 1949.
3. Introduction to Electric Theory (book), R. G. Fowler. Addison-Wesley Publishing Company, Cambridge, Mass., 1953.
4. Electric Fields (book), W. E. Rogers. McGraw-Hill Publishing Company, Inc., New York, N. Y., 1954.
5. Outlines of Physical Chemistry (book), E. H. Getman, F. Daniels. John Wiley & Sons, Inc., New York, N. Y., 1943.
6. Electricity and Magnetism (book), Sir James Jeans, Cambridge University Press, London, England, 1925.
7. Electricity and Magnetism (book), J. C. Maxwell. Dover Publications, Inc., New York. N. Y. (original edition, 1891); new edition, 1954.
8. Dielectric Materials and Applications (book), A. R. von Hippel. The Technology Press of the Massachusetts Institute of Technology and John Wiley & Sons, Inc., New York, N. Y., 1954.
9. Analytical Experimental Physics (book), H. B. Lemon, M. Ference, Jr. The University of Chicago Press, Chicago, Ill., 1943.
10. Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents. American Petroleum Institute, Publication *RP2003*, New York, N. Y., 1956.
11. Electrical Charges Produced by Flowing Gasoline, S. S. Mackeown, V. Wouk. *Industrial and Engineering Chemistry*, American Chemical Society, Easton, Pa., vol. 34, June 1942.
12. Theory of Electric Polarisation (book), C. J. F. Bottcher. Elsevier Publishing Company, Amsterdam, Netherlands, 1952.
13. Electrical Phenomena at Interfaces (book), J. A. V. Butler (Chester Beatty Research Institute, London SW 3, England). The Macmillan Company, New York, N. Y., 1951.

The Diode Reactance Modulator

G. F. MONTGOMERY



◄ Fig. 1. Basic single-diode reactance modulator.



▼ Fig. 2. Variation of susceptance, conductance, and control current with control voltage, single diode.

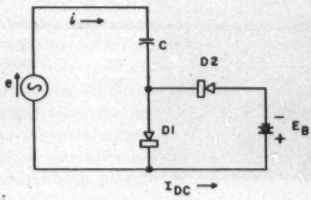
CERTAIN COMBINATIONS of a capacitor with one or two diodes can be operated as voltage-controlled reactances. Such modulators are used as frequency controls, frequency modulators, and phase modulators. Their performance can be calculated easily if ideal diodes and lossless circuit elements are assumed.

Fig. 1 is the diagram of one modulator that is both useful in practice and a convenient starting point for analysis. Generator e represents the source, which is typically the resonant circuit of an oscillator whose frequency is to be modulated. E_B represents the modulating voltage; since in practice this voltage varies slowly compared with e, the analysis can be made with E_B as a d-c parameter. In general, the diode current is not sinusoidal. A direct current I, the result of partial rectification of the sinusoidal voltage e, exists in the direction shown. Both currents are functions of E_B.

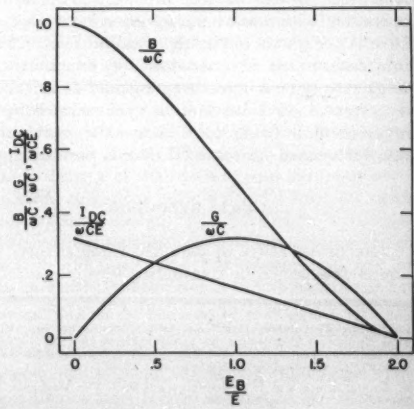
Since there are no resistances in the circuit, the energy delivered during one period of e equals the energy consumed in E_B. Also, during this period, no net charge is accumulated by capacitor C. If L is a very large inductor, two integral equations containing the generator current i can be written which are equivalent to these statements. An additional equation for i can be found by assuming that the diode conducts during only a part of each cycle. A simultaneous solution yields the ratios E_B/E and $I/\omega CE$ as functions of the angle of conduction θ, where E is the amplitude of the source voltage, and ω is 2π times the frequency of the source.

The fundamental component of i, that is, the component of i at frequency $\omega/2\pi$, is the current of principal interest. Once θ has been found, $i(\omega t)$ is known, and the coefficients of the fundamental component can be found from the Fourier series formulas. The fractional susceptance of the modulator $B/\omega C$ and its fractional conductance $G/\omega C$ can then be evaluated. Fig. 2 shows a plot of these ratios as functions of E_B/E for the circuit of Fig. 1.

Similar calculations are easily made for modulators using two diodes, Figs. 3 and 4. These circuits are simple and convenient to apply, particularly with semiconductor diodes. Recent applications include an automatic frequency control for a frequency-modulation receiver and a frequency modulator for a transistor wireless microphone.



◄ Fig. 3. Parallel-diode reactance modulator.



▼ Fig. 4. Variation of susceptance, conductance, and d-c control current with control voltage, parallel diodes.

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A Digital and Pictorial Photographic Electronic Recorder

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A data recording system using both photographic and digital techniques is described. Applications of this type of system may range from the simple installation of code wheels attached to existing shafts on equipment and camera with recording head, to the installation of nonloading, highly accurate transducers with servo units and special timing generators.

A FILM DATA RECORDING SYSTEM combining the advantages of pictorial and digital recording has been developed. This combination of photographic and digital techniques provides a record containing a picture of the event of interest with the adjacent frame used to record a digital code. The code may be used to provide a record of instrumentation, time, or other identifying information.

Fig. 1. Recording head.

The advantages of film recording include high density recording (systems of 6,000 bits per square inch are in operation, with work reported on systems approaching 10^6 bits per square inch); high readout rates (200-kc bit rate systems are in operation and experimental two megacycle systems have been in operation); and high data storage per cubic foot, as demonstrated by microfilm files now being used. Automatic search through film reels based on recorded data is possible.

DATA RECORDING

THE UPPER LIMIT of data recording density on the film is determined by considering film tolerances, registration accuracy in recording and reading, effects of dirt, dust, and scratches, and complexity of readout and recording equipment. Experience with film reading projects indicates that data spots 10 mils by 10 mils are a practical size for the digital data. For 16-mm film, this corresponds to rows of data of approximately 40 bits, or 4,000 bits per inch of 16-mm film. Successful recorders and readers have been designed and operated with code bit dimensions of 10 mils by 10 mils. While it is certainly possible to provide a much greater density of data per square inch of film, the considerations of film dimensional stability with temperature, humidity, and age for systems intended for commercial-type use indicate that these dimensions are practical limitations. In addition, for data rows in excess of 40 bits, the problems of providing a clock become somewhat more difficult.

Miniature incandescent lamps (0.069-inch diameter) have been used for the recording-head light source. They are available from a number of companies and are a standard item in use for medical applications. Lamps of this type have been tested with over 4.6 million cycles of on-off operation without failure, and continuous operation of over 800 hours without failure. The power reqirement for these lamps is 90 milliwatts at 1 volt. Requirements for this recorder system include analog-to-digital conversion, with the digital output capable of providing 1 volt at 90 milliamperes. Examples of encoders that can be used include the commutating code wheel shaft position-to-digital code converter, of which a number of types exist. Relay devices can be used, as can transistor switches driven from a flip-flop register.

At The Magnavox Research Laboratories, several film data programs are in process or have been completed. One system recently completed provided for the recording of airborne instrumentation data consisting of up to 90 bits of data at rates up to 2,880 bits per second. In addition, pictorial data are collected to show what the pilot observed during the tests in question. The airborne equipment consisted of analog-to-digital conversion equipment, timing information generator and the controls necessary to start and stop recording based on events detected in the aircraft. The recording rates required were 16 and 32 frames per second.

Development work on design of a recording head included study of electroluminescent-cell light sources, small cathode-ray tubes, and miniature incandescent lamps. After consideration of the limitations of each of these recording methods and some experimental work,

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it was determined that the incandescent lamps recorder was the better choice for this application. Fig. 1 shows the recording-head assembly used for this airborne application. The recording head contains 90 lamps and is approximately ½ cubic inch in volume. Fig. 2 shows the type of record obtained. For 16-mm film, one and one-half frames are used for picture area and one-half frame is used for data. The picture and digital data are recorded simultaneously through the shutter.

In the airborne recorder application three voltage signals, whose amplitudes were proportional to the quantity to be measured, were used to provide drive signals for three servo units. Commutating-type code wheels were used for the shaft position-to-digital conversion. This system provided a digital record on the film of ±15 degrees measured in 1-mil increments. In addition, measurements or indications were provided for type of armament, time, slip or skid, prerun condition, and armament action. The airborne recorder is shown in Fig. 3.

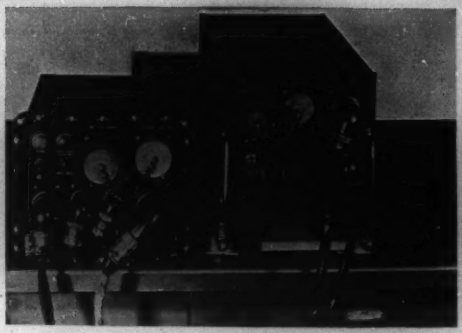

Fig. 3. Airborne recorder.

DATA READER

Several methods of reading or extracting the information from the film have been investigated. These methods are classified in three groups: optical–mechanical, cathode-ray tube, and storage tube. Each of these has definite advantages, depending on the application in question. Reading rates, tolerances, and reliability are important, and greatly affect the method to be considered.

Of the three types mentioned, the optical–mechanical is perhaps the simplest in regard to method of readout. An experimental system was constructed using a rotating drum on which were mounted 15 mirrors, each consecutive mirror being mounted at a slightly different angle. The information to be read consisted of 15 rows of information with six bits in each row. The information itself was represented as 10-mil squares, separated by 10 mils. The field of information, 0.290 by 0.110 inch, was optically magnified 10 times and projected on the face of the rotating mirrors. Each mirror in sequence would move its predetermined row of information across the face of a photomultiplier tube and appear at the output as a signal. The upper limits of read rates are determined by the speed of the rotating drum, the amount of information, precision mounting of mirrors, frequency limit of the sensing device, and mechanical tolerances.

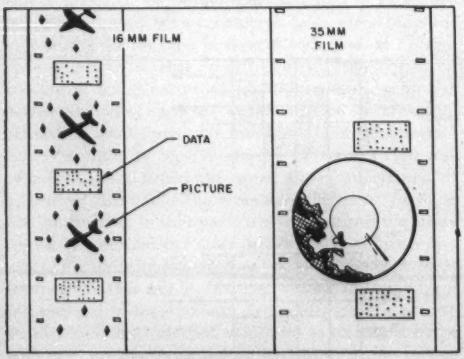

Fig. 2. Sample data record.

For data-reading systems of greater density or for those systems requiring greater readout rates, the electronic-type readers have advantages over optical–mechanical systems. An example is the flying-spot scanner, a cathode-ray tube for providing a scanning raster, with a multiplier phototube used to convert light changes to electric signal changes. The scanning raster may be made larger than the data field to be covered, thus allowing for registration inaccuracies.

Storage tubes, such as the image–orthicon, iconoscope, and vidicon have been studied for the film reader function. The iconoscope was made nearly obsolete with the development of the image–orthicon tube. This tube has a much higher sensitivity and efficiency rating compared to that of the iconoscope. In addition, the image–orthicon seemed unfeasible from the standpoint of price and its vulnerability to damage. The studies indicated that the vidicon storage tube would be the most practical of the three. Its cost is about $150, whereas the iconoscope ranges from $400 to $600 and the image–orthicon is about $1,400. The vidicon is also less susceptible to damage as the result of scan failure or over-illumination. It is more compact and allows for more miniaturization in design.

A system using the vidicon as the film-reading device is under development, and preliminary tests are in progress at The Magnavox Research Laboratories. Tests have indicated that a 40- by 60-bit array, with each bit 10 mils square, is well within the limits of the reading device. The information matrix is projected on the photoconductive layer on the face of the vidicon. The photoconductive layer is then scanned from within and

Fig. 4. Flying-spot scanner film reader.

signals corresponding to the light areas in the information array are presented at the output. These signals are amplified and are available for use in the decoding or sensing equipment. The vidicon is capable of a 600-line resolution. In this application a 290-line raster is used, which is within normal operation specifications. Effective spot size is approximately 2 mils; linearities in horizontal and vertical sweeps are 2%. Linearities of 1% can be obtained with a high-quality specially designed yoke. The 40- by 60-bit array is scanned in 16 milliseconds. An overlap of 10% in both the horizontal and vertical directions is used to relax tolerances from misalignment of the film. The useful area on the face of the vidicon is a rectangle 0.5 by 0.375 inch, requiring an optical reduction from film to vidicon. The resultant four scans per data row assure a preferred scan more nearly in the center portion of a row.

The reading rate for the system described is 150,000 bits per second. Higher rates could be achieved by reducing the size of the coded bits and increasing the number of bits in the array. The reader developed for the airborne recorder system automatically reads the film frame by frame and provides a printed record and punched paper tape output. Readout was accomplished by using an electromagnetic short-persistence cathode-ray tube with a 100-line raster displayed in its face. The light from the flying spot which traces out this raster is focused on the film data area by an object lens which reduced the raster size by a factor of 10. The image of the raster exposed on the film was such that an overlap of the data area was provided in both the horizontal and vertical directions. This overlap takes care of registration inaccuracies which may be associated with the film transport mechanism. The light passing the data field in the scanning process is collected by a collector lens, and projected on the photocathode surface of a multiplier phototube. Thus, light of varying intensity is translated into a signal voltage of corresponding amplitude. The signal voltage so developed is amplified and fed into the system for decoding and printout. This reader is shown in Fig. 4.

SCANNING PATTERNS

For systems with short data rows, a free-running clock of the pulsed oscillator or multivibrator type is adequate. By "clock" is meant the provisions of a gating waveform as interrogation pulse to sample the signals from the film data pick-up device. This is necessary to identify adjacent bits on the film. Longer data rows (those of 10 bits or more) require either very tight tolerances on film dimensions and readout systems or a clock that is, in some way, synchronized with the film scanner.

Several methods of accomplishing a clock and film data tie-in are possible. A beam-splitting optical system can be used in which a fixed clock target is swept by the light source that simultaneously sweeps the data card. In this way, the clock and data card signals are independent of time variations of sweeping circuitry. There is a space tolerance, however, that requires rather tight tolerances of the data film with respect to the fixed clock target. For the 10- by 10-mil case, this registrator tolerance will approach 1 mil when the effects of film data dimensional change and recording location tolerances are included in the over-all problem. This method can be used only in systems which include a sweeping light source, such as the cathode-ray tube reader. A self-clocking method using multivibrator circuits for the clock has been designed in which the film information changes are used to modify the clock rate or to shift the clock in a direction to resynchronize the clock. In

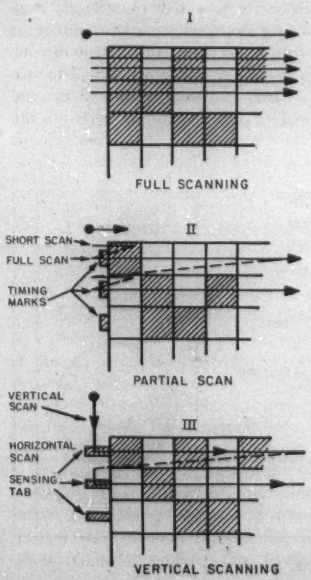

Fig. 5. Scanning patterns.

this system film information is compared with the clock pulse. If the clock is late, it is shifted to occur earlier. This method requires use of a digital code that insures film data changes occurring every few bits.

Several methods of scanning the film information have been studied (Fig. 5). Of the various methods studied, the three which appeared feasible were: a full scan with a conventional raster such as used in the system designed and presently in use, a combination partial and full scan, and a combination vertical and horizontal scan. The full-scan method has already been described. For the partial scan, two horizontal sweep rates would be employed, the shorter sweep continuing until the timing mark was reached. The signal from the interception of the timing mark would enable the long or readout sweep to traverse the row of information, and readout will occur. The shorter sweep would again take place and the same procedure would be repeated. The partial-scan method has the advantage that it would decrease the bit rate to approximately half that of the full-scan method, since there are approximately half as many total scanning lines per scanning raster. One disadvantage would be that two separate horizontal sweep systems would be necessary. They could be achieved with special sweep circuit and yoke design that would add to the complexity of a system.

The third method would be to use a vertical scan which would continue to move in its vertical path until it intercepted a sensing tab. The signal derived from this interception would be used to enable the horizontal sweep, and readout of the information would occur. This method has one advantage over the previous two in that the bit rate would be approximately one third that of the full-scan method, and also less than that of the partial scan. There are added disadvantages, however, not only because special sweep circuit and yoke designs are needed, but also because the trace would be required to return to within a close tolerance of its initial starting point. This tolerance would necessarily depend upon the application in question. Also, the long-term drift associated with tube and component decay, plus variations in operating voltage, would present a problem. However, these last two methods are feasible and have been considered from the standpoint of lowering the bit rates in systems with rates of 1 megacycle or greater, so that lower frequency circuits may be employed. Some means of identifying or sensing the center portion of each row of information must be considered. A small square bit, half the size of the information bits, could be located directly in front of each row of information. When this small bit is intercepted, it will serve to enable the readout equipment to sense the information in that particular row. Another method would be to have the rows separated by a space and utilize the techniques employed in the system previously mentioned. This would, however, reduce the amount of information to some extent, depending on the spacing required. A third method would be to employ a stripe with tabs projecting in the horizontal direction in line with each row of information present. The signal derived from the stripe, plus the tab, would serve to enable the readout circuit and cause the information to be sampled.

SUMMARY

THE APPLICATION of this type of equipment may range from the simple installation of code wheels attached to existing shafts on equipment and camera with recording head, to the installation of nonloading, highly accurate (one part in 100,000) transducers with servo units and special timing generators. The film-reader equipment may be designed simply to read the coded data and provide printed records, or it may include pictorial display by projection or by kinescope monitors remotely located. For data file systems, an automatic search feature can be provided which, on command, searches the film frame by frame until the desired information is located. Preliminary studies indicate that search of 40 frames per second of data, made up of 600 bits per frame, can be achieved through use of techniques developed for existing machines. Even greater reading rates appear feasible with extensions of the existing methods.

The practical systems developed include 10- by 10-mil spot size, data rows of up to 40 bits, output rates of up to 200 kc, recording rates of 64 frames per second, with 90 bits per frame. Incandescent-lamp recording has been used, and either cathode-ray tube or vidicon readers have been employed.

REFERENCES

1. Television Engineering (book), D. G. Fink. McGraw-Hill Book Company, Inc., New York, N.Y. 1952.

2. IRE Standards on Television: Methods of Measurement of Aspect Ratio and Geometric Distortion. *Proceedings*, Institute of Radio Engineers, New York, N.Y., vol. 42, no. 7, July 1954, pp. 1098-1103.

3. Vidicon for Film Pickup, R. G. Neuhauser. *Journal*, Society of Motion Picture and Television Engineers, New York, N.Y., vol. 62, no. 2, Feb. 1954.

U. S. Army's Space Sentry

The Space Sentry, giant new radio transmitter of the Army Signal Corps, constructed in co-operation with the Naval Research Laboratory, has bounced signals from the moon to insure close tracking of the Army's Explorer I and other projected United States satellites. Calibration tests conducted during January 1958 assured that Minitrack listening posts throughout the Western Hemisphere and on the West Coast of Africa would be tuned precisely to the same frequency. The tests also were used to check the internal computing systems of Minitrack stations. These operations are vital for coordinated observation of the satellites.

Signals were transmitted from Fort Monmouth, N. J., to the moon on alternate days, each having a 5-hour test period, between moonrise and moonset, bracketing the moment when the moon was at the same longitude as that of the station.

Thermal Converter Time Constant and Response Time

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THE DYNAMIC CHARACTERISTICS of a thermal converter* for measuring alternating current or voltage are of some importance in a number of applications. Of these, the time constant and response time are the characteristics most often required. The change of emf of a thermal converter after a step change in heater current is only approximately exponential, so that the definition as well as methods of measuring these quantities must be specified.

One definition of time constant t_a is simply the time required for 63% of the change of emf to take place after a step change in heater current. A second definition is given by

$$t_b = \frac{1}{E}\int_0^\infty e\,dt$$

where e is the difference between the final and the actual emf at the time t, and E is the difference between the final and initial emf's. This is the same as t_a for a truly exponential function.

The response time of an instrument is the time required for the pointer to come to apparent rest. Two definitions of response time have been proposed for thermal converters. One is the time required for 90%, and the other for 99% of the change in emf to occur after a step change in heater current.

Several methods of measuring the dynamic characteristics of thermal converters were considered, from the viewpoints of practicality, accuracy, and the commercial availability of apparatus.

The first method consisted of obtaining and scaling oscillograms of the output emf of each converter as a function of elapsed time after a prescribed step change in heater current. Step changes of zero to the prescribed current and vice versa were used (current switched on and off, respectively). The oscillograph consisted of a direct-writing galvanometer, with a chart drive of 5, 25, and 125 millimeters per second and a d-c amplifier which provided a chart deflection of 40 divisions at 5 millivolts, with a noise level less than 10 microvolts. The oscillograph was calibrated at each measurement, and the t_a and the 90% response time were measured from these calibrated oscillograms. The 99% response time of a few converters was measured by increasing the gain of the amplifier and offsetting the zero.

A 5-range, portable fluxmeter with sensitivities from 0.1 to 10 millivolt-seconds per division in a 15-ohm circuit was used to measure t_b. Under appropriate conditions, the change of deflection of such an instrument divided by the total change of emf is

$$D/E = (K/E)\int_0^\infty e\,dt = Kt_b.$$

where e is the net emf in the circuit. The constant K is readily evaluated.

The time constants of the converters tested ranged from 0.1 second for a bridge-type converter to over 8 seconds for a special long-time-constant converter having a large insulating bead between the heater and thermocouple. For the usual converters in the milliampere ranges, time constants ranged from 0.5 to 1.5 seconds, and were about 0.2 to 0.3 second for converters of higher range.

The results indicated that for most converters the measured time constants depended upon the magnitude and the direction (whether up or down) of the step change in heater current, with variations up to 20% observed and variations up to 10% rather common. Theoretical analysis indicated that such variations are very probably caused by nonlinearities (temperature coefficients) in the heater and thermocouple. For most converters the difference between t_a and t_b was less than 5% under the same test conditions, but for some vacuum-type converters of high range (200 to 1,000 milliamperes), differences up to 50% were observed. These larger differences are believed to be caused by temperature rises of the junctions between the heater and lead-in wires.

Discussions with manufacturers and users indicate that an accuracy of 10% should generally be sufficient in specifying time constants, although 5% may be required in some cases. Because of the influences noted, the conditions of test should be specified. A step change from zero to rated current is suggested as a standard condition.

For those instrument applications in which the response time is of more importance than the time constant, a definition is suggested as the time required for 99% of the change in emf to take place after a step change from zero to rated current.

Because the same method and equipment may be used to measure the 63% and 99% response, the arbitrary 63% definition of time constant is believed by the author to be somewhat preferable to the definition based on the integral of emf.

Digest of paper 58-11, "The Definition and Measurement of the Time Constant and Response Time of Thermal Converters," recommended by the AIEE Indicating and Integrating Instruments Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Communication and Electronics*, July 1958.

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*A thermal converter (often called a thermoelement or thermocouple) consists of a thermojunction in thermal contact with an electric heater so that the emf serves as a measure of the heater current.

Relaying Tapped Substations for High-Voltage Faults

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THE NEED for relaying a small-capacity substation tapped to a high-voltage transmission line for faults on the line is not a frequent occurrence. Most substations tapped to high-voltage transmission lines (Fig. 1) supply essentially passive or nonmotor loads and present no problem in case a fault occurs on the high-voltage transmission line. The need for special consideration of relaying at a tapped substation is encountered when a substation supplies power to a subtransmission or distribution system with considerable connected rotating machinery, and high-speed reclosing of circuit breakers is desired on the high-voltage transmission line. Typical examples of such substations are as follows:

1. A station supplying power to a low-voltage system with connected generation operating in parallel with the high-voltage transmission system, such as a municipality or a large industrial plant.
2. A station supplying power to large synchronous motors, as in an industrial or pumping plant.
3. A station supplying power to a low-voltage system where the load is predominantly small induction motors.

When high-speed reclosing is required on the high-voltage transmission line, relaying which can disconnect the substation within a few cycles must be applied. High-speed relaying is required for the following two reasons:

1. Successful high-speed reclosing of circuit breakers following a high-voltage line fault requires that all sources of fault current be disconnected from the faulted portion to allow the fault arc path to deionize before the circuit is re-energized. For successful 20-cycle reclosing, a deionization time of about 8 to 12 cycles is required; this requires high-speed relaying of about 3 cycles when 5-cycle circuit breakers are used.
2. Synchronous machines can be damaged severely by out-of-phase synchronizing, which would be the likely result of reclosing the high-voltage circuit before the machines are disconnected from the faulty circuit.

The small tapped system must be protected against having to furnish line charging current to the large system and against reclosing out of synchonism. Relaying for such a purpose, if fast enough, could be used for clearing a fault to permit reclosing. It should be emphasized that the latter requirement is the more severe one because time must be allowed for deionization of the fault arc. Relays that are reliable and fast enough to clear the fault in time to permit reclosure will provide a safety margin in the protection against reclosing out of synchronism. This safety margin is the dead time needed for deionization of the fault arc.

There is a definite advantage in using voltage relays rather than current or impedance relays at tapped substations for detection of main line faults. The reach of the voltage relays is nearly independent of the amount of rotating machine capacity in operation at the substation. In the U.S. Bureau of Reclamation's systems, the number of induction motors in operation depends largely on pumping requirements for irrigation purposes, which vary greatly throughout the year.

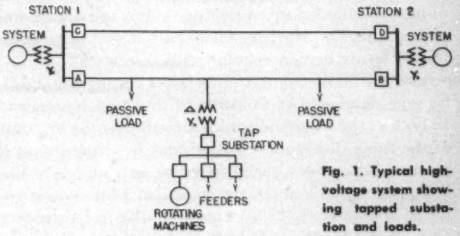

Fig. 1. Typical high-voltage system showing tapped substation and loads.

When considering relaying at a tap substation connected to a line with carrier relaying at the main terminals, one might think that some scheme involving carrier should be used at the substation. There are many factors that make carrier relaying at the tapped station an undesirable solution. These include high first cost, a continued high maintenance cost for the tapped station, and the added inconvenience of more equipment to keep in operation. With the usual directional comparison carrier blocking relay scheme on the main line, there is the possibility of adding a transfer trip scheme, but this would require completely new equipment at the main terminals and would be quite costly.

Phase-to-phase faults can be detected by instantaneous undervoltage relays. Three relays are used connected to receive line-to-line potential on the main line. Acceptable sources are potential devices connected to the main line or potential transformers connected to the low voltage bus. In a typical installation, undervoltage relay settings of the order of 80 to 90% of normal voltage are usually required to assure high-speed operation for all faults on the main line.

Ground faults can be detected by an overvoltage relay operating from a source of zero-sequence voltage. In a typical installation, a relay pickup of about 10% is required for simultaneous tripping.

Digest of paper 58-25, "Relaying Tapped Substations for Faults on High-Voltage Transmission Lines," recommended by the AIEE Relays Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Power Apparatus and Systems*, Apr. 1958, pp. 73-78.

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A New Finite Difference Stability Criterion

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A MAJOR DIFFICULTY in the numerical solution of partial differential equations of the parabolic or hyperbolic types by means of finite difference approximations is the tendency of the solution to be unstable under certain conditions. Thus, a small error (such as a round-off error), arising at some point in the computation procedure may tend to become larger and larger as the computation progresses, until the error terms completely overshadow the desired solution, making it worthless. Some finite difference approximations appear to be stable under any condition, others are always unstable, whereas some are stable only if the spacing intervals satisfy certain requirements.

The two most familiar criteria for testing for stability were developed by Hildebrand[1] and Von Neumann.[2] In both of these methods, it is assumed that the solution of the finite difference equation may be expressed as a product of functions, each depending only on one of the independent variables of the equation. This general solution is then analyzed to determine what requirements must be met by the coefficients of the equation, in order that a computational error decay, as one of the independent variables (generally time), goes to infinity.

A different approach to the stability problem follows from the recognition that the voltage or current distribution of a network of resistors arranged in a regular pattern may be expressed compactly by a finite difference equation. Conversely, a finite difference equation may be considered to have an electrical network analog. It follows that any instability in the finite difference network must be reflected as electrical instability in the analogous electrical network. Where a small computational error in a numerical finite difference computational procedure gradually tends to grow to infinity, so in the electrical network the appearance of a small voltage or current "noise" may be expected to grow indefinitely.

Upon suitable rearrangement, a finite difference approximation of a partial differential equation can be identified with a regular network of resistors, which may have negative as well as positive magnitudes. If the electrical analog contains only positive resistors, the network is stable under all conditions. It is the presence of active elements in the form of negative resistors which introduces the possibility of electrical instability. By making reference to previously developed active network concepts, it can be shown that a regular resistance network containing negative resistors is stable only if the algebraic sum of the magnitudes of all resistors comprising a typical node or loop of the network satisfies certain conditions.

The application of the electrical stability considerations for resistance networks then permits the formulation of a general criterion for computational stability of finite difference equations as follows:

1. Arrange the finite difference equation in the form

$$1(w_{m+1,n} - w_{m,n}) + a(w_{m-1,n} - w_{m,n}) + b(w_{m+2,n} - w_{m,n}) \ldots + c(w_{m,n+1} - w_{m,n}) + d(w_{m,n-1} - w_{m,n}) + e(w_{m,n+2} - w_{m,n}) \ldots = 0 \quad (1)$$

where the subscript m refers to a bounded space coordinate, and examine the coefficients 1, a, b, c, d, etc.

2. If all the coefficients are positive, the equation is stable.

3. If some of the coefficients are negative, a sufficient condition for stability is that the algebraic sum of all the coefficients be negative.

As an example, consider the one-dimensional wave equation

$$\frac{\partial^2 w}{\partial x^2} = \frac{\partial^2 w}{\partial t^2} \quad (2)$$

and its customary finite difference expansion

$$w_{m+1,n} - 2w_{m,n} + w_{m-1,n} = k^2 (w_{m,n+1} - 2w_{m,n} + w_{m,n-1}) \quad (3)$$

where

$$k = \frac{\Delta x}{\Delta t}, \quad w_{m,n} = w(x,t), \quad w_{m+1,n+1} = w(x+\Delta x,\ t+\Delta t)$$

Equation 3 is rearranged as

$$(w_{m+1,n} - w_{m,n}) + (w_{m-1,n} - w_{m,n}) - k^2 (w_{m,n+1} - w_{m,n}) - k^2 (w_{m,n-1} - w_{m,n}) = 0 \quad (4)$$

The stability criterion then specifies that

$$(+1 \ +1) < (+k^2 \ +k^2) \quad \text{or} \quad k > 1 \quad (5)$$

This approach is readily applied to more complex difference equations and problems with more than two independent variables.

A chief merit of the electric circuit theory approach lies in the ease with which it may be applied. The finite difference equation is merely rearranged in the form of equation 1 and the coefficients of this equation examined. Generally, the condition for stability can then be deduced by inspection.

REFERENCES

1. Methods of Applied Mathematics, F. B. Hildebrand. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1942, pp. 328-45.

2. A Study of the Numerical Solution of Partial Differential Equations, G. G. O'Brien, M. S. Hyman, S. Kaplan. *Journal of Mathematics and Physics*, Cambridge, Mass., vol. 29, no. 4, Jan. 1952, pp. 223-51.

Digest of paper 58-60, "An Electric Circuit Theory Approach to Finite Difference Stability," recommended by the AIEE Basic Sciences Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Communication and Electronics*, May 1958.

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Transistor Count-Rate Systems

L. E. WEISNER

Use of transistors in nuclear counting systems results in increased reliability, reduced space and power requirements, and lower initial cost. All-transistor systems have been built for use with boron trifluoride counters, Geiger counters, and scintillation probes.

EARLY IN 1956, a program was undertaken at the Du Pont Savannah River Plant to develop transistor count-rate systems for use with boron trifluoride counters, Geiger counters, and scintillation probes in monitoring process conditions. Interest was directed specifically toward development of small, reliable instruments which would require practically no maintenance.

These instruments had to be small, because a shortage of panel space existed in most of the locations where radiation counting systems were needed. In addition, they had to be reliable and maintenance-free, inasmuch as access to the instruments would be limited by radiation hazards. Conventional particle-counting systems do not meet these requirements because they are bulky and contain a large number of vacuum tubes, which are subect to occasional failure.

ADVANTAGES OF TRANSISTOR INSTRUMENTS

THE TRANSISTOR SYSTEMS which have been developed and are in use at the Savannah River Plant have the following advantages over conventional systems using vacuum tubes:

1. High reliability
2. Small size
3. Low power requirements
4. Lower cost

Transistor instruments have one disadvantage not normally encountered in vacuum tube instruments; i.e., they are temperature sensitive. This disadvantage has been overcome in the instruments in use at the Savannah River Plant by circuits designed to compensate for temperature changes over the range of 20 to 50 C.

BF_3 COUNTER SYSTEM

A TRANSISTORIZED COUNTING SYSTEM was developed for use with a BF_3 counter to measure neutron flux. This system is now being used to determine the concentration of plutonium within process vessels located in areas having limited access. One instrument has been operating continuously for a period of more than a year without requiring maintenance or recalibration. Other instruments have required no maintenance after continuous service of more than five months. Vacuum-tube instruments in similar service have required maintenance about every two months, plus frequent recalibration.

The transistorized instrument has a range of 0 to 1,000 counts per second, an input sensitivity of 1 to 5 millivolts, an accuracy of $\pm 2\%$ of full scale, and a d-c voltage output capable of driving a 0- to 50-millivolt recorder. The system consists of a linear amplifier, a count-rate circuit, a calibration circuit, and a high- and low-voltage power supply. Fig. 1 is a schematic wiring diagram of the counting system.

The amplifier uses five *2N34* transistors to give an over-all current gain of 1,000. The first transistor, *TR1*, is used as an emitter–follower to obtain a high input impedance to match the BF_3 counter. Transistors *TR2*, *TR3*, and *TR4* are connected as a voltage amplifier with direct-coupled negative feedback from the emitter of *TR4* to the emitter of *TR2*. The positive pulse output of transistor *TR4* is coupled to an emitter–follower, *TR5*, in order to match the input impedance of the count-rate circuit.

Two primary considerations were involved in developing the bias arrangements used in these instruments: (1) the input impedance of each stage had to be high enough to match the preceding stage, and (2) the circuit gain had to be stable over a temperature range of 20 to 50 C. Tests were made using various fixed-emitter-current bias circuits until a good compromise between temperature stability and high input impedance was achieved. Fig. 2 shows the circuit developed for a typical cascade amplifier stage.

The input transistor stage presented a special problem in that an input impedance of several hundred thousand ohms was required to match the BF_3 chamber output. A self-biased emitter–follower was developed using a bias-current resistor which was carefully selected to provide optimum temperature compensation.

The counting rate system is basically a monostable flip-flop circuit. A simplified diagram of the circuit is shown in Fig. 3. Transistor *TR1* is biased to conduct in its quiescent state, and transistor *TR2* is biased to cut off. The application of a positive triggering pulse to *TR1*

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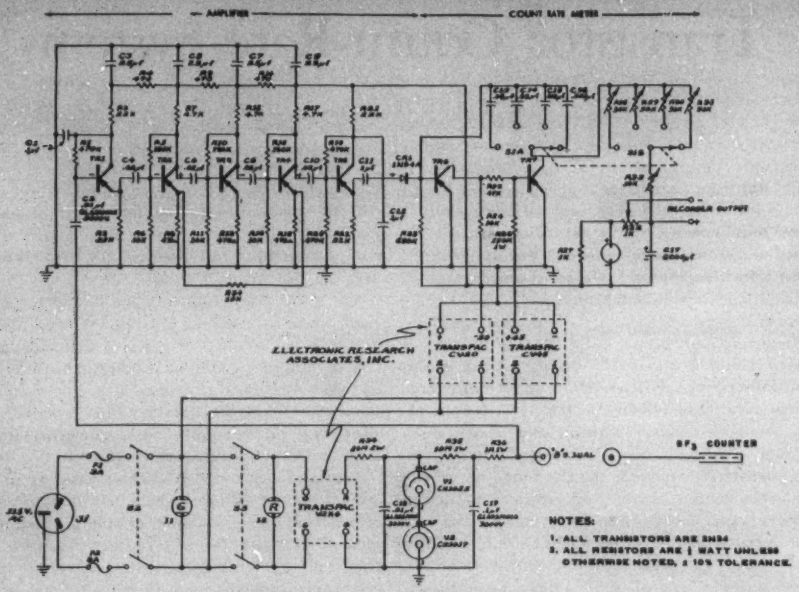

Fig. 1. Schematic wiring diagram, BF_3 counting system.

cuts off *TR1* and turns on *TR2*. The reduced collector voltage of *TR2* causes the range capacitor *C1* to discharge through *R1*. The current through the base resistor *R1* of *TR1* keeps *TR1* cut off. When the exponentially decreasing current through *R1* falls below the value that keeps *TR1* cut off, *TR1* starts to conduct and the circuit triggers back to its original state.

As the circuit returns to its quiescent state, the range capacitor *C1* charges through the range resistor *R6*. Inasmuch as the total charge transferred is the same for each pulse, the current through the recorder resistor *R7* and the 200-microampere indicating meter is directly proportional to the pulse rate. The *RC* time constant of the range capacitor *C1* and resistor *R6* determines the range of the instrument.

Transistorized power supplies provide the necessary supply voltages for the amplifier and BF_3 counter. Regulation of the high-voltage supply is achieved by the addition of an *R-C* filter and two corona tubes connected as a parallel regulator.

GEIGER COUNTER SYSTEM

A TRANSISTOR COUNT-RATE CIRCUIT was developed for use with a Geiger counter to measure beta–gamma activity. A schematic wiring diagram of the instrument is shown in Fig. 4.

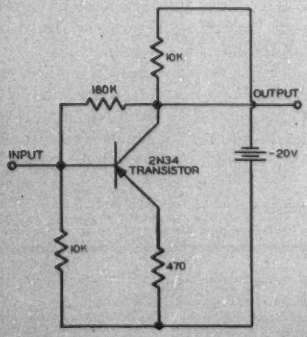

Fig. 2. Typical cascade amplifier stage.

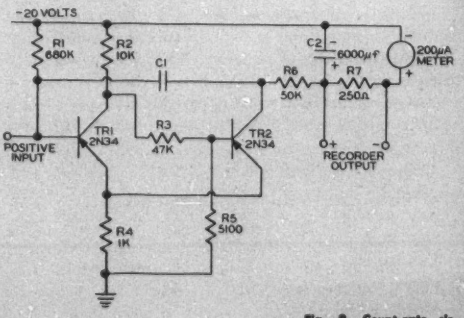

Fig. 3. Count-rate circuit, simplified diagram.

This instrument is very similar to the neutron count-rate meter with the exception that it is triggered by negative pulses. Since the output pulses of Geiger tubes are negative and sufficiently large to trigger the count-rate circuit directly, *2N35* n-p-n transistors were used in the Geiger counter circuit. The circuit is now used in a health physics survey instrument, and its low power requirement results in a battery life of 1,200 hours.

SCINTILLATION COUNTING SYSTEM

THE COUNT-RATE CIRCUIT developed for use with scintillation probes is similar in its operation to the BF_3 counter circuit previously described, except that a gain (or discriminator) adjustment is included.

This instrument has a range of 0 to 1,000 cycles per second, an input sensitivity of 0.01 volt, an accuracy of 2% of full scale, and an output which drives a 0- to 50-millivolt recorder. The amplifier is temperature compensated over the range of 20 to 50 C.

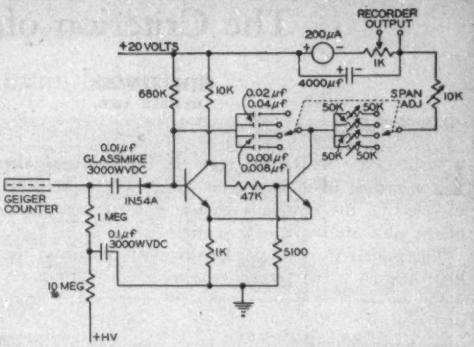

Fig. 4. Count-rate circuit for Geiger counter.

CONCLUSION

TRANSISTORIZED NUCLEAR INSTRUMENTS which have been developed and placed in operation at the Savannah River Plant have proved more reliable than comparable vacuum-tube instruments and have operated in locations which would not accommodate conventional instruments. Transistorized instruments have been found to cost less to fabricate than comparable conventional instruments, and their low power requirements have made their use highly desirable in portable health physics instruments.

"Gas Light" for Brussels Fair

The combining of hydrogen and oxygen gases to produce electricity is among the scientific marvels being demonstrated at the Brussels World's Fair. A special exhibit of its fuel cell, capable of producing electrical energy directly from the chemical energy of gases, was assembled by National Carbon Company, Division of Union Carbide Corporation, at its research laboratories in Parma, Ohio, where development work on the unique power source is being continued. Further improvements have been made in the efficiency of the fuel cell since it was announced last September.

By designing the hydrogen and oxygen electrodes, which are made of specially treated porous carbon, as concentric cylinders to nestle within each other, researchers have produced a fuel cell that will operate on hydrogen gas and the oxygen in the air. Thus, the necessity for a source of pure oxygen is eliminated. Although this method of operation is still not practicable for commercial use, it represents an important milestone in the development of the fuel cell into a commercial and industrial source of power. Dr. C. E. Larson, National Carbon's research vice-president is shown examining the Brussels demonstration unit which is being used to light up a bank of sealed-beam lamps to indicate visually the power being produced.

The Criterion of Economic Choice

P. H. JEYNES
MEMBER AIEE

L. VAN NIMWEGEN

ECONOMY STUDIES may be classified initially according to their general nature as (1) problems of selecting the economic choice; and (2) appraisals of the profitability of new ventures.

The preferred technique for solving problems in the first category is the "revenue requirements" approach, more commonly but less accurately called the annual-cost method. Short-cut procedures which undertake to evaluate savings directly, rather than as differentials in revenue requirements of competing alternatives, have been found to invite trouble.

Problems of the second type sometimes call for a different technique. Attempting to discover the economic choice by solving directly for maximum profitability, as some popular procedures do, may result in the wrong choice of alternatives, or incorrect quantitative solutions.

No drastic innovations are proposed; the objective is to improve the organization of well-established basic principles in order to develop an integrated and comprehensive technique that is universally applicable, mathematically rigorous, and quantitatively correct to the extent permitted by the accuracy with which component items of cost can be forecast. A great practical advantage is that this approach facilitates taking short cuts with safety, and encourages sound time-saving approximations.

The proposed procedure for making effective engineering economy studies is outlined in two steps as follows:

1. Determine which alternative is *most economic*, and by how much. The criterion is the present worth of competing revenue requirements.
2. Decide which alternative is *most desirable*, in the light of the foregoing criterion, together with other considerations not reducible to dollars.

Some subjects to be considered, on which very little has been written, are as follows:

1. The intimate and fundamental relation between the accountant's income statement and the engineer's estimated revenue requirements.
2. The effect on financial decisions of possible future changes in price levels.
3. The fact that it is impossible to predict the life of any particular property unit, just as it is impossible to predict the life of an individual person, and the mathematics necessary for quantitative evaluation of the effects of average life expectancy.
4. Determination of the appropriate period for study, and helpful applications of the concept of projections "to eternity."

There remain a number of awkward problems that have troubled analysts who recognize the financial effects of retirement dispersion, such as

1. The relation between service life and revenue requirements, which is not linear even though "straight-line" depreciation accounting may be used.
2. The fact that expressing annual costs in per cent, as is common practice, means constantly decreasing dollars per year of service from given equipment. The usual assumption of constant dollars per year firmly implies that retirements will be replaced as they occur, in kind, and at the same unit price.
3. The difficulty of defining "one lifetime" of a project composed of equipment of all ages, resulting from replacement of scattered retirements.

The term "revenue requirements" means the revenues that must be obtained in order to pay all bills, together with an acceptable rate of return on the investors' committed capital in the enterprise.

The proposal having minimum revenue requirements satisfies every definition of "most economic." No plan earning less than an acceptable rate of return can be regarded as economically desirable by owners of the business. Adopting a less economic proposal means either selling the company's product at the same price, whatever alternative is adopted, and losing money; or having to sell the company's product at a higher price to obtain the same acceptable rate of return.

It may be observed that the estimate of revenue requirements is not a prediction of actual revenues, which may be greater or smaller. Adopting the plan having minimum revenue requirements maximizes earnings from any revenue obtainable above that figure; it also puts the firm in best position to meet competition (i.e., to cut prices without reducing return below the acceptable rate) or, if a regulated utility, to comply with a rate order. The criterion applies equally well to regulated or nonregulated businesses.

To summarize, the owners of a business (its investors) define what they regard as economic when they stipulate the rate of return that they find acceptable on their committed capital on the enterprise. Establishing that acceptable rate of return is an essential part of the analysis.

Digest of paper 58-115, recommended by the AIEE System Engineering Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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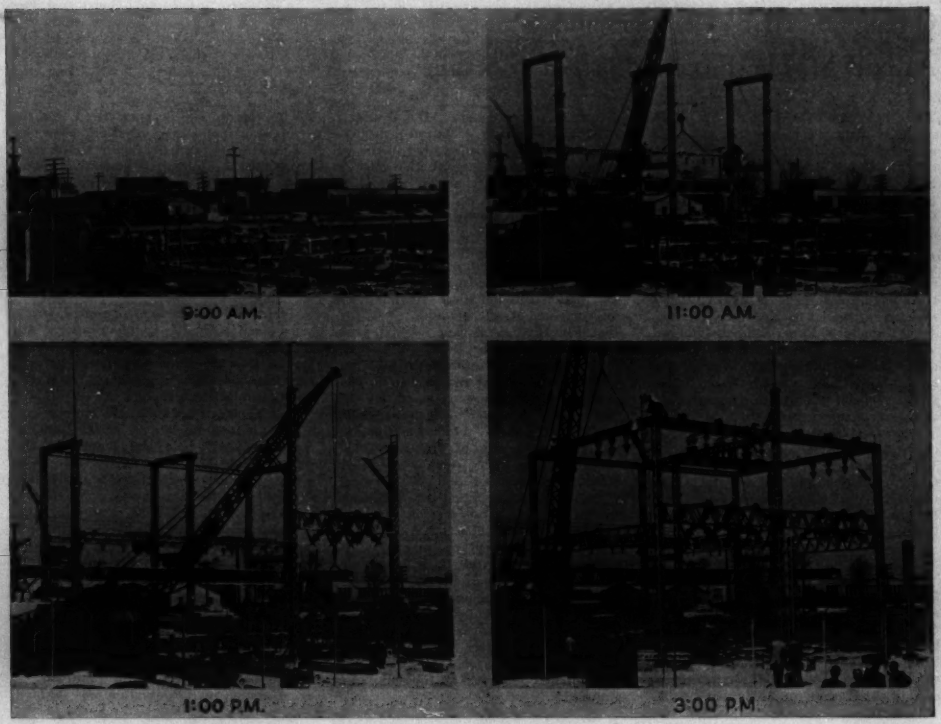
Pictorial Review

Prefabricated Aluminum Substation



One of the world's first prefabricated all-aluminum electric substations erected recently in Alma, Mich., took just 6 hours to raise after various sections were ground assembled *(four time-sequence panels)*.

Only one third the weight of galvanized steel (143 vs 443 pounds), the prefabricated trusses and structural parts were handled easily by construction crews *(below right)*. The "Alrectic" substation design was developed in aluminum by Handley-Brown Co., Jackson, Mich., with design and engineering assistance from Consumers Power Co., Alma, Mich., and Kaiser Aluminum & Chemical Sales, Inc., Chicago, Ill. Several midwestern and eastern utility companies sent official observers.

The Alrectic system utilizes standard truss beams, fixtures, and other parts. Trusses are 1-foot square, or one foot by 2½ feet, and available in lengths up to 60 feet. Of welded construction and consisting of four extruded aluminum chords supported by lacing, sides and ends are precision punched with holes spaced at 3-inch intervals. A portable crane, which did not move from its position, was used.

Vertical columns and cross beams were assembled on the ground and bolted together with strong aluminum alloy fasteners. The crane lifted each "arch" upright onto concrete piers *(left)* where it was bolted securely. Horizontal trusses were placed between the arches forming a wing of the substation.

Insulators, switches, and control devices were also ground assembled. Once the crane had lifted the subassemblies, the crew could easily push the units around manually into position.

The positioning of the last horizontal truss was a test of the prefabricated substation's precision engineering. It fit perfectly.

Kaiser Aluminum Photos

INSTITUTE ACTIVITIES

Over 600 AIEE Members and Guests Attend Middle Eastern District Meeting

THE WASHINGTON, D. C., SECTION of the Institute was host to over 600 AIEE members and guests at the Middle Eastern District Meeting, held April 28-30, 1958, at Washington's Sheraton Park Hotel. "Engineering in the Nation's Capital" was selected as the theme for the meeting.

In addition to the general session, 27 technical sessions were held on a wide range of subject matter of interest to electrical engineers and scientists. Social events included a smoker held Monday evening, April 28, and a dinner-dance the following evening. A varied program for the ladies included a sightseeing tour of the city, a special visit to the White House, several luncheons, and a demonstration of flower arrangements.

Inspection trips were made to the National Bureau of Standards and the WRC-TV transmitter in Washington; the Naval Ordnance Laboratory, White Oak, Md.; the Army Package Power Reactor, Fort Belvoir, Va.; and the David Taylor Model Basin, Carderock, Md.

General Session

C. H. Giroux, general chairman of the District 2 Meeting, opened the general session Monday morning and introduced Col. A. C. Welling, engineer commissioner for the District of Columbia, who gave a brief welcoming speech. Short addresses were then given by M. M. Moore, chairman of the Washington Section, and B. R. Teare, Jr., vice-president, AIEE District 2.

AIEE President W. J. Barrett mentioned some of the problems involved in the expansion of a large organization such as AIEE in a rapidly changing technology. AIEE has taken the lead in a program set up to clarify the organization of the engineering profession as a whole. This program, he stated, has received a great deal of favorable attention and comment.

The principal address, entitled "The International Geophysical Year and the Instrumented Earth Satellite," was presented by Dr. L. V. Berkner (F '47), president, member of the Board of Trustees, and chairman of the Executive Committee of Associated Universities, Inc., in New York City. The basic purpose of IGY, Dr. Berkner stated, is to "look at the earth and see it as a planet." The ideal time for such observations is at "sun-spot maximum," a condition which very nearly exists at the present time.

Dr. Berkner described in detail the work currently in progress in Antarctica and showed color slides taken at various bases there. He went on to discuss the organizational setup of the IGY program, in which 67 nations are participating. The cost of the IGY program has been estimated at approximately $300 million.

Many major discoveries have already been made as a direct result of this program. However, he emphasized, it will take years to synthesize all the data being gathered.

Schutz Photo

DISCUSSING THE PROGRAM of the AIEE Middle Eastern District Meeting held April 28-30 at the Sheraton Park Hotel, Washington, D.C., are: *(left to right)* L. V. Berkner, principal speaker at the opening general session; B. R. Teare, AIEE vice-president representing the Middle Eastern District; W. J. Barrett, president of AIEE; M. M. Moore, chairman of the Washington Section of AIEE, hosts to the meeting, and C. H. Giroux, general chairman of the meeting.

In closing, Dr. Berkner stated that the successful launchings of satellites by the United States and the Soviet Union have provided a considerable amount of useful scientific data. He expressed gratification over the amounts of data which have been exchanged to date, and also expressed the hope that additional information would be released when available.

Technical Sessions

Over 100 papers were presented, covering such topics as communications, nuclear engineering, automation, illumination, weapons development, power generation and system engineering, naval testing, and management.

In a paper presented in a Monday session on communications, M. E. Littleton of the Chesapeake and Potomac Telephone Company described a dial telephone system installed on Smith Island, 10 miles off the Maryland coast in Chesapeake Bay. The system, combining two radio-carrier terminals and associated central office equipment, has a capacity of 200 individual lines. In a Tuesday session, P. F. Crabill, Jr., of the same company, described the work involved in telecasting the 1957 presidential inauguration ceremonies. The estimated audience for the telecast was 50 to 60 million people. Included in the equipment were 27 complete microwave sets and 61 amplifiers.

A session on illumination was devoted to roadway lighting. E. B. Karns of the Westinghouse Electric Corporation discussed new developments in light sources and optical systems. He claimed that 90% of the nation's streets are receiving substandard lighting, and that gaseous discharge lamps should replace the incandescent lamp. Advantages include higher efficiency and longer life. J. W. Young, lighting consultant of Natick, Mass., said that the task of modernizing existing roadway illumination is impressive. However, we have more and better tools to do the job, such as effective vapor illuminants which accent economy and contribute attractiveness through color properties.

Among a group of papers on service reliability was "Improving Continuity of Service on Overhead Distribution Systems" by W. E. Wilkinson of the Baltimore Gas & Electric Company. He claimed that the greatest single factor contributing to service interruptions is inadequate tree clearance. He recommended that tree clearance operations be engineered and administered by a separate organization headed by a person with considerable experience in distribution construction and field engineering, together with a knowledge and appreciation of trees. L. B. Crann of the Rural Electrification Administration discussed service reliability on rural distribution

systems. The forecasted "unprecedented" load growth in rural areas in the next 10 years will depend, to a great extent, upon the ability of power systems to give a high level of service. Improving main-circuit conditions to a point where the circuit is essentially trouble-free should result in a remarkable improvement in over-all service reliability on the feeder. H. P. Noble, Jr., of the Virginia Electric & Power Company stated that the growth in population immediately south and southwest of Washington, D. C., in the past decade has resulted in what has amounted to "almost a crash program" in order to supply the area's electrical needs. The planning and construction program instituted to meet current and future needs were described.

In a Tuesday afternoon session on management, L. A. Kilgore of Westinghouse stressed the importance of the study of human relations by those engaged in engineering leadership. "Management," he stated, "must continue to give considerable thought to providing opportunities for deserved recognition." Hathaway Watson of Booz, Allen & Hamilton, discussed the need for effective management of research and development programs. He feels strongly that more, not less, management direction in this important field is required if research is to meet its full promise.

A Tuesday afternoon session on marine transportation featured papers by representatives of the Bureau of Ships, U. S. Navy. A paper by J. R. Cole and M. L. Garbacz described special power and lighting systems on aircraft carriers. The authors observed that today's aircraft carrier power system is 10 times greater than that of the first carrier, built in 1930, as the result of higher ship speed, larger hulls, and more electronic equipment. In addition, special problems have been introduced by guided missiles systems on carriers now under construction. Another paper, by E. W. Lusby and C. L. Straub, covered the use of ungrounded neutral electrical systems aboard naval ships. The chief advantage is the elimination of ground faults. However, more maintenance is required, and additional facilities and personnel must be provided.

East Central District Meeting Held in Huntington, May 13-15, 1958

HUNTINGTON, W. Va., major river port and railway center, situated in the heart of a rapidly expanding industrial section, was host to the East Central District Meeting of the AIEE, May 13-15, 1958. The Prichard Hotel served as headquarters.

A total of 312 members, nonmembers, and guests attended.

The technical program offered a wide variety of papers covering such diverse engineering interests as a-c distribution for underground mining, cathodic protection, high voltage transmission, induction heating, safety, and computers.

Inspection trips included a tour of the Ravenswood Works of Kaiser Aluminum & Chemical Corporation, and a visit to one of the world's largest steam generating stations at Kyger Creek, near Gallipolis, Ohio. The program also provided a full calendar of events for the ladies who particularly enjoyed the Early-Bird Reception Dinner and the moonlight cruise on the Ohio River aboard the steamer *Avalon*, an old Mississippi River packet.

General Session

The Honorable H. L. Frankel, mayor of Huntington, extended his warm greetings to the assemblage gathered in the Georgian Terrace of the Frederick Hotel for the General Session luncheon. During the luncheon, Mayor Frankel presented the key to the city to AIEE President W. J. Barrett. President Barrett, introduced by J. H. Reeves, chairman of the General Session luncheon, noted the growth and progress of the Institute since its founding in 1884. (The Institute will celebrate its 75th anniversary next year.) The technological dependence of modern life has pushed the engineer into a position of leadership and responsibility. The AIEE has projected reorganization of the Institute to help meet this new situation, President Barrett said. He also reported steady progress toward the construction of the new headquarters.

The keynote address was delivered by J. K. Hodnette, executive vice-president of Westinghouse Electric Corporation.

A major problem facing today's engineer, he declared, is the sharing of benefits of improved industrial technology with the consumer in the form of lower prices. He estimates, for example, that "in 20 years the electric utility industry will be using 3 to 5 times as much coal as it uses today," despite the fact that one fourth of the nation's installed generating capacity may be in nuclear power plants. To achieve such increases at low costs, he pointed out, will certainly be one of the major engineering challenges in the coming decades.

Technical Sessions

Industrial Lighting. Fluorescent lamps have constantly been improved through the years resulting in more efficient, more durable, and greater lumen output light sources. Recently, changes in gas fill, electrical construction, phosphor composition, and bulb shape have produced a series of fluorescent lamps operating at wattages and lamp currents believed impractical only a few years ago. W. H. Johnson, Westinghouse Lighting Division, Cleveland, Ohio, in his paper "Application of Super-Hi Lamps and High Frequency to Interior Lighting," discussed some of the problems in application and operation of these lamps and pointed out the future potential afforded by the operation of fluorescent lamps at frequencies above 60 cps.

Also presented at this session was a talk by H. L. Logan, Holopane Co., Inc., on "Fundamental Principles of Industrial Lighting."

A-C Distribution in Underground Mines. As mechanization of mines increases, so do the electrical problems in the industry, A. C. Lordi, Westinghouse Electric Corporation, East Pittsburgh, Pa., pointed out in his paper "Power Distribution for A-C Mines." The magnitude and concentration of electrical loads increase at the most remote points of the distribution system in

SHOWN at the AIEE East Central District Meeting are: (left to right) J. C. Strasbourger, member of the AIEE Board of Directors; Mayor H. L. Frankel of the City of Huntington; AIEE President W. J. Barrett; H. H. Kerr, vice-president, District No. 11; P. C. Kelsey, general chairman of the District Meeting; and N. S. Hibshman, secretary of the Institute.

VIEW *above, left* of the General Session luncheon held Tuesday, May 13, at the Frederick Hotel in Huntington, W. Va., during the East Central District Meeting of the Institute. *Above, right:* Mayor H. L. Frankel *(right)* presents the key to the city to AIEE President W. J. Barrett during the General Session luncheon which opened the AIEE District Meeting.

mines and are continually moving farther from the power source, he remarked. It thus becomes "more and more important that we carefully examine the power system so electrical energy can satisfactorily power mining machinery.

Major items of electrical apparatus involved in mining, he said, are: the surface substation, portable switchhouses, underground power centers, and underground portable capacitor packs, including equipment to correct power factor.

In another session on the same topic, R. M. Buckeridge, Goodman Mfg Co., noted that the a-c (alternating current) mining machine is here to stay. In his paper "A-C Powered Mining Machines," he pointed out that "the advantages of a-c powered machines more than outweigh the disadvantages." He added that the mine operator, however, has a broader picture which must include power generation, transmission, distribution, power cost, investment, safety, etc.

Safety. L. H. Harrison of the U. S. Bureau of Mines said that his agency is promoting research to "develop a continuous monitoring system for detecting methane" gas in mines. Such a system, he said, in his paper "Some Aspects of Safety in the Use of Electrical Equipment in Coal Mines," properly integrated with improved methods of ground fault and cable protection, and designed to remove power from the face areas, should virtually eliminate the principal source of gas ignitions and cable fires in our mines.

In a companion paper, Dr. Peter Safar, chief of the Department of Anesthesiology of the Baltimore City Hospitals, spoke on "New Data on Resuscitation." He said recent experiments have led to the conclusion that manual resuscitation methods should be discontinued in favor of mouth-to-mouth methods.

Telemetering Systems. "Today's Industrial Telemetering Systems," by H. Wittenberg, Control Corp., describes a few of the many telemetering devices which are available to industry today. With scientific knowledge advancing as fast as it has in the past few years, it is not easy to predict accurately what the future will hold for the telemetering systems of tomorrow, the author pointed out. Undoubtedly the trend is toward increased emphasis on the use of digital telemetering systems. Speed of operation will be increased because of the greater use of modern data processing and computing systems, Mr. Wittenberg said. Miniaturization also will be an important factor in the design of future telemetering systems.

Other papers were "A Reverse Application of Storage Type Telemetering, E. W. Dennis, Cincinnati Gas & Electric Co.; and "Telemetering KWH for use in Tie Line Load Regulation," A. L. Hayley, Jr., Louisville Gas & Electric Co.

AIEE Board of Directors Holds Spring Meeting in Washington, D.C.

FINANCE was the major subject before the AIEE Board of Directors at its Spring meeting, held this year on April 30, at the District No. 2 meeting in Washington, D. C. The budget for 1958-59 was adopted calling for an expenditure of a record $1,849,443.00 between May 1, 1958, and April 30, 1959. Various measures designed to insure efficient spending and to stimulate income enough to keep the books in balance were adopted.

In view of the mounting cost of the expanding services, the Board established the policy that, insofar as practicable, the activities and services of the Institute should be financially, individually self-supporting. In line with this policy, the Publications Department was authorized to charge $2.50 for initial member annual subscriptions to the Bimonthly Transactions, now supplied without charge. Additional subscriptions will cost $5. Nonmember prices will go from the present $5 to $8 per annual subscription. Only the student Bimonthly prices remain unchanged. Transactions will be priced at $4 for each part to members, or $10 for the set of three parts. This new price schedule becomes effective August 1, 1958, which means that it will not apply to most member subscriptions for the current year beginning May 1, 1958.

The Board approved revisions in the retirement system for Institute employees to bring it into line with modern practices.

Important actions affecting Districts and Sections were taken. The composition of the District Executive Committees was revised to provide more effective co-operation between the Institute committees and the District organizations. The functions, privileges, and prerogatives of the members of the District Executive Committee were altered and defined. The practice of rebating to the Sections all entrance and transfer fees will be continued for the fiscal year 1958-59. The extension of meeting bonuses beyond the 30-meeting limit, will also be continued for another year.

Progress was reported in the reassignment of District territory to equalize the load on District officers. The Board gave encouragement to the Administration Department to proceed with plans that indicate the possible formation of an additional two Districts in the next two or three years, bringing the total to 15.

Formal approval was given to the addition of the American Institute of Chemical Engineers (AIChE) into the United Engineering Trustees Corporation, making AIChE the fifth "Founder Society." Resolutions of congratulations were also addressed to AIChE on the occasion of the 50th Anniversary of its founding to be celebrated this year. Past-President N. E. Funk was designated AIEE official delegate to

AIEE Future Meetings

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference (Exhibit)*
Statler Hotel
Los Angeles, Calif.
August 5-8, 1958

AIEE-IRE-NBS Electrical and Radio Standards Conference*
University of Colorado and NBS (Dormitory Accommodations)
Boulder, Colo.
August 13-15, 1958

Pacific General Meeting*
Hotel Senator
Sacramento, Calif.
August 19-22, 1958

AIEE-NEMA National Electrical Insulation Conference*
Pick-Carter Hotel
Cleveland, Ohio
September 3-5, 1958

Fifth UPADI Convention
Montreal, Que., Canada
September 2-6, 1958

World Power Conference Sectional Meeting
Montreal, Que., Canada
September 7-11, 1958

Petroleum Industry Conference
Baker Hotel
Dallas, Texas
September 15-17, 1958
(Final date for †TP—closed, ‡CP Syn.—July 2, CPMs—July 11)

Power Industry Computer Application Conference
King Edward Hotel
Toronto, Ont., Canada
September 15-17, 1958
(Final date for †TP—closed, ‡CP Syn.—July 2, CPMs—July 11)

AIEE-IRE Industrial Electronics Conference
Park Shelton Hotel
Rockham Memorial Auditorium
Detroit, Mich.
September 24-25, 1958
(Final date for †TP—closed, ‡CP Syn.—July 11, CPMs—July 21)

AIEE-ASME National Power Conference
Statler Hotel
Boston, Mass.
September 28-October 1, 1958
(Final date for †TP—closed, ‡CP Syn.—July 15, CPMs—July 23)

AIEE-IRE-EIA-SMPTE National Electronics Conference
Hotel Sherman
Chicago, Ill.
October 13-15, 1958
(Final date for †TP—July 15, ‡CP Syn.—July 30, CPMs—Aug. 8)

Machine Tools Conference
Statler Hotel
Hartford, Conn.
October 13-15, 1958
(Final date for †TP—July 15, ‡CP Syn.—July 30, CPMs—Aug. 8)

Fall General Meeting
Penn-Sheraton Hotel
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—closed, ‡CP Syn.—Aug. 12, CPMs—Aug. 22)

Magnetism and Magnetic Materials Conference
Sheraton Hotel
Philadelphia, Pa.
November 17-20, 1958
(Final date for †TP—Aug. 19, ‡CP Syn.—Sept. 3, CPMs—Sept. 12)

AIEE-IRE-ACM Eastern Joint Computer Conference (Exhibit)
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958
(Final date for †TP—Sept. 4, ‡CP Syn.—Sept. 19, CPMs—Sept. 29)

AIEE-IRE Second National Symposium on Communication Systems (Exhibit)
Colonial Inn-Desert Ranch
St. Petersburg, Fla.
December 3-5, 1958
(Final date for abstracts and summaries—Aug. 1)

AIEE-IRE-ASQC-EIA National Symposium on Reliability and Quality Control
Bellevue-Stratford Hotel
Philadelphia, Pa.
January 12-14, 1959
(Final date for †TP—Oct. 14, ‡CP Syn.—Oct. 29, CPMs—Nov. 7)

Winter General Meeting
Statler Hotel
New York, N. Y.
February 1-6, 1959
(Final date for †TP—Nov. 3, ‡CP Syn.—Nov. 18, CPMs—Nov. 28)

AIEE-IRE-U of P Transistor and Solid-State Circuits Conference
University of Pennsylvania
Philadelphia, Pa.
February 12-13, 1959
(Final date for †TP—Nov. 13, ‡CP Syn.—Nov. 28, CPMs—Dec. 9)

EJC Nuclear Congress
Cleveland, Ohio
April 5-10, 1959
(Final date for †TP—Jan. 5, ‡CP Syn.—Jan. 20, CPMs—Jan. 30)

South East-South Central District Meeting
Dinkler Plaza Hotel
Atlanta, Ga.
April 8-10, 1959
(Final date for †TP—Jan. 8, DPMs—Feb. 2)

East Central District Meeting
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, DPMs—Feb. 16)

Rubber and Plastics Conference
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, ‡CP Syn.—Feb. 6, CPMs—Feb. 16)

Empire District Meeting
Hotel Syracuse
Syracuse, N. Y.
April 29-May 1, 1959
(Final date for †TP—Jan. 29, DPMs—Feb. 20)

AIEE-IRE-EIA-WCEMA Joint Electronic Components Conference
Benjamin Franklin Hotel
Philadelphia, Pa.
May 6-8, 1959
(Final date for †TP—Feb. 5, ‡CP Syn.—Feb. 20, CPMs—March 2)

Middle Eastern District Meeting
Lord Baltimore Hotel
Baltimore, Md.
May 19-21, 1959
(Final date for †TP—Feb. 18, DPMs—March 13)

AIEE-ISA-ARS-IAS National Telemetering Conference
Brown Palace-Cosmopolitan Hotel
Denver, Colo.
May 24-27, 1959
(Final date for †TP—Feb. 23, ‡CP Syn.—March 10, CPMs—March 20)

Summer and Pacific General Meeting
Olympic Hotel
Seattle, Wash.
June 21-26, 1959
(Final date for †TP—March 23, ‡CP Syn.—April 7, CPMs—April 17)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Authors Guide*. For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N.Y.

the anniversary celebration of AIChE, to be held in Philadelphia, Pa., during the week of June 22-27, 1958.

AIEE's own 75th anniversary will occur in May 1959. The Board heard a report on plans for the observance from a committee headed by Dixon Lewis of Pittsburgh, Pa.

At this meeting, 20 new Fellows were elected. Their pictures and biographical sketches will appear in *Electrical Engineering*. Professor Ramachandra Rao of the Indian Institute of Science was elected Local Honorary Secretary for South India. C. H. Linder was elected AIEE representative on the Board of Directors of Engineers Joint Council, effective August 1, 1958, to replace L. F. Hickernell. The following were appointed a Committee of Tellers to canvass the ballot for officers of the Institute for 1958-59: D. C. Aker, chairman, C. R. Boytano, W. E. Broadwell, G. L. Bullwinkel, W. E. Coover, E. W. DuBois, H. M. Evans, M. C. Johnson, R. G. Procopio, H. A. Schumacher.

The Board of Directors approved a plan for the exchange of papers with the Engineering Institute of Canada (EIC). In accordance with this plan, conference-type papers by AIEE authors will be made available for use in the annual meeting of the EIC and papers by members of EIC will be accepted through the regular machinery of the Technical Operations Department for inclusion in programs of AIEE. The co-ordination of this co-operative plan will be delegated to the TOD representative for District No. 10 of the AIEE.

The next meeting of the Board of Directors was to be held in connection with the Summer General Meeting in Buffalo, June 27, 1958.

Increased Prices for Subscriptions to Bimonthly Publications and Transactions

SINCE the bimonthly publications were inaugurated in July and August 1952, there has been a considerable inflationary increase in the costs of printing, paper, salaries, and overhead for the staff to turn out the increased volume of these publications. Since these publications were first issued, *Communication and Electronics* and *Power Apparatus and Systems* have increased from 7,500 to 17,000 editions and *Applications and Industry* has increased from 5,500 to 13,000 editions. Also, the number of pages has increased from 2,068 to an average of 2,866 in a compact format over the past five years.

The Institute is a nonprofit organization. It derives no net income from the sale of its publications to members. The bimonthlies and *Transactions* are now being produced and sold at considerably less than cost. This is an undue burden on the Institute's finances. In view of the situation, the Board of Directors at its meeting of April 30, 1958, approved increases in subscription prices as shown in the accompanying table to become effective August 1, 1958. All existing subscriptions and those received before that date will be honored at the present prices but the increased prices will become effective for all new and renewed subscriptions received on or after that date. All nonmember and company subscriptions should be accompanied by remittance of the prices shown and if any of these originate from foreign countries they should be accompanied by the extra amounts indicated for foreign postage with both the indicated subscription price and the postage payable in advance in New York exchange.

The AIEE *Transactions* are bound in cloth, gold embossed with a stiff cover. Each part contains all of the officially approved papers which have been presented at the technical meetings during the previous calendar year and which have been recommended for publication by the technical committees. Bound volumes of the *Transactions* are available in April or May of the following year. Parts I and II contain the papers published in the two bimonthly publications, *Communication and Electronics* and *Applications and Industry* in the six consecutive issues beginning with March and ending with January of the following year. Part III, *Power Apparatus and Systems*, contains all of the papers in the six consecutive issues of this bimonthly publication from April to February of the following year.

Increases in Subscription Prices to Bimonthlies and *Transactions* Approved by Board of Directors April 30, 1958
Effective August 1, 1958

Bimonthly Publications	Member Prices (annually)	Nonmember Prices (annually)
Communication and Electronics	$5.00†	$8.00‡
Applications and Industry	5.00†	8.00‡
Power Apparatus and Systems	5.00†	8.00‡

†Members may receive one subscription to any *one* of the bimonthlies for $2.50. The balance of the $5.00 subscription price shown above will be paid by application of his annual dues for the year of the subscription. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional subscriptions will be at the $5.00 rate shown above.

‡Subscription price and 50¢ extra for foreign postage both payable in advance in New York exchange.

Single copies may be obtained when available	$1.50 each	$1.50 each

AIEE *Transactions*		
Part I. *Communication and Electronics*	$4.00	$8.00**
Part II. *Applications and Industry*	4.00	8.00**
Part III. *Power Apparatus and Systems*	4.00	8.00**
Annual combination subscription to all three parts	10.00	15.00***
Annual combination subscription to any two parts		12.00***

**Subscription price and 75¢ extra for foreign postage both payable in advance in New York exchange.

***Subscription price and $1.00 extra for foreign postage both payable in advance in New York exchange.

Electrical Engineering and *Transactions*	
An annual combination subscription to both publications (effective August 1, 1958)	$24.00§

§Subscription price and $2.00 extra for foreign postage both payable in advance in New York exchange.

Discount 25% of above nonmember prices to college and public libraries. Publishers and subscription agencies 15% of above nonmember prices. For available discounts on Standards and special publications, obtain price lists from Order Department at Headquarters. Send all orders to:

Order Department
American Institute of Electrical Engineers
33 W. 39th St., New York 18, N. Y.

First National Conference on Electrical Insulation Planned

The First National Conference on the Application of Electrical Insulation, with the participation of manufacturers, distributors, and users, is to meet at Cleveland, Ohio, on September 3-5, 1958. It will be the first meeting of this type ever held in the United States attracting everybody either directly or indirectly interested in electrical insulation, both for military and civilian purposes. Attendance of between 1,500 and 2,000 is anticipated.

The Conference is cosponsored by the AIEE and the National Electrical Manufacturers Association (NEMA). The purpose is to provide a meeting ground for the maker and user of electrical insulation where there can be a mutual interchange of practical technical information on a formal and informal basis, thereby leading to better utilization of existing materials, to better direction in the development of new materials, and to better methods of interchanging information.

Activities at Cleveland will include technical sessions, a commercial trade show exhibiting electrical insulation materials, and technical exhibits by manufacturers of electrical equipment.

In addition to the cosponsors, other

technical societies and trade associations are participating in the counseling and preparation of the program.

Headquarters will be in the Pick-Carter Hotel. Technical sessions will be held concurrently in the Statler-Hilton and Pick-Carter hotels. Technical exhibits will be in the Statler-Hilton Hotel, and commercial exhibits will be in the Pick-Carter Hotel.

Technical papers to be delivered will cover a wide variety of subjects in the field of electrical insulation and the application of insulating materials in rotating machinery, transformers, controls and instrumentation, and in electronic equipment.

The Conference committee includes: J. R. Perkins, E. I. du Pont de Nemours & Co. (Inc.), general chairman; H. H. Chapman, Jr., Owens-Corning-Fiberglas Corp., program chairman; C. L. Christiansen, Dow-Corning Corporation, exhibits chairman; T. F. Hart, Union Carbide Corporation, publicity chairman; W. G. Hoffer, Johns-Manville Sales Corporation, publications chairman; Walter Hugger, Sun Chemical Company, hospitality chairman.

The AIEE is represented on the Planning Committee by R. S. Gardner, assistant secretary, Technical Committee Activities, and NEMA by J. F. Miller, managing director.

The Cleveland Committee for the Conference includes Lanier Greer, Reliance Electric & Engineering Company, chairman; K. L. Wheeler, Cleveland Electric Illuminating Company, chairman, Cleveland Section, AIEE; C. E. Logston, Reliance Electric & Engineering Company, treasurer; A. D. Steele, Minnesota Mining & Manufacturing Co., hospitality; H. L. Williams, Cleveland Electric Illuminating Co., registration; George Bamberg, The Glastic Corporation, publicity; S. F. Moat, The Glastic Corporation, technical exhibits.

Greater New York Business Campaign for United Engineering Center Under Way

PLANS for the new $10 million United Engineering Center to be erected on United Nations Plaza were announced to 150 New York business leaders at a luncheon held May 2 at The Waldorf-Astoria.

W. H. Byrne, president of Byrne Associates, Inc., and general chairman of the Greater New York Business Campaign, announced that a total of $3,079,200 has already been contributed to the campaign from industry and the membership of the five Founder Engineering Societies.

Other speakers included Mayor R. F. Wagner, honorary chairman; Dr. A. B. Kinzel, president of the American Institute of Mining, Metallurgical, and Petroleum Engineers and vice-president (research) of Union Carbide Corporation; C. G. Dandrow, Industrial Campaign chairman in New York and vice-president (customer relations) of Johns-Manville Sales Corporation; R. C. Patterson, honorary campaign vice-chairman and commissioner of Commerce and Public Events; and Col. C. E. Davies, executive director of the United Engineering Center project.

Mr. Byrne reported on the status of the national campaign which started in November 1957 with a dinner at the Waldorf-Astoria for top industrial leaders of the nation.

"Since November of last year, an organized fund-raising effort has been organized to underwrite this project," he said.

"A campaign among the membership of the Founder and Associate Societies to raise $5 million is now soliciting initial gifts and will appeal to all members this year.

"A campaign to raise $5 million from industry is now soliciting companies throughout the nation.

"Local counterparts of the national industry campaign are being organized across the country in an effort to solicit all businesses and industries that may be interested. Our objective, of course, is to at least reach and hopefully surpass the $5 million goal. Our responsibility in the Greater New York Business Campaign is to extend the opportunity to participate to business and industry in New York, Connecticut, and northern New Jersey.

"We are fortunate in having the new Center in our area. Because of our proximity to the new building, we will receive greater benefits through the engineering profession. Also, many phases of business will profit because of the thousands of visitors that will be attracted. Other areas as far away as San Francisco are organizing campaigns the same as we are doing here. Our unique position of having this great Center created in our midst demands that we demonstrate our full support of this program."

The new United Engineering Center will be constructed on United Nations Plaza on the blockfront between 47th and 48th Streets. Ownership and management will be by United Engineering Trustees, Inc., the joint corporate agency of the five Founder Societies: AIEE; American Society of Civil Engineers; American Institute of Mining, Metallurgical, and Petroleum Engineers; American Society of Mechanical Engineers; and the American Institute of Chemical Engineers.

In referring to the new Center, Mr. Byrne said that it would serve as the focal point of the engineering profession.

"Industry will benefit through contributions of engineering personnel made aware of the latest ideas through more efficient communication of engineering knowledge," he said.

"Devoted to the continuing achievement in the search for knowledge, the Center will serve as the core of the engineering profession. Not only will adequate facilities be provided for performing its functions, but also sufficient provision will be made to include continued growth of the services of the profession."

Commenting on the need for the new Center, Col. Davies remarked that when

Department of Commerce and Public Events

THE GREATER NEW YORK BUSINESS CAMPAIGN for the new United Engineering Center got under way at a luncheon at the Waldorf-Astoria Hotel on May 2. City officials saluting the profession of engineering and warmly endorsing the campaign to fund construction of the new national headquarters included Mayor R. F. Wagner, Commissioner R. C. Patterson of the Department of Commerce and Public Events, and Abe Stark, president of the City Council. Shown with the model of the new Center are: (*left to right*) J. J. Theobold, deputy mayor; Commissioner Patterson; W. H. Byrne, chairman of the Greater New York Business Campaign; Mayor Wagner; Mr. Stark; and C. F. Preusse, City administrator.

AIChE Inducted as Founder Society

INDUCTION of the 50-year-old American Institute of Chemical Engineers (AIChE) as a Founder Society by United Engineering Trustees, Inc. (UET) marked the first time in 42 years that a national engineering society has been admitted to membership. Attending ceremonies connected with the signing of Founders' Agreements were: (*seated at table, left to right*) D. W. R. Morgan, past president, American Society of Mechanical Engineers (ASME), representing J. N. Landis, president, ASME; A. B. Kinzel, president, American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME); W. J. Barrett, president, AIEE, and also president, UET; G. E. Holbrook, president, AIChE; and L. R. Howson, president, American Society of Civil Engineers (ASCE). Secretaries (*standing, left to right*) are: O. B. Schier, II, ASME; E. O. Kirkendall, AIME; S. W. Marras, UET; F. J. Van Antwerpen, AIChE; and W. H. Wisely, ASCE.

the present Engineering Societies' Building was opened on 39th St. in 1907 there were only 16,000 members.

"Today," he said, "the Founder and Associate Societies who are gathered together in this project have a membership totalling over 250,000 including 36,000 students.

"As the membership of the Societies has multiplied," he continued, "the headquarter's staff has necessarily grown with the result that present facilities are far from adequate in the amount of space they provide.

"Furthermore," he said, "the building is not designed efficiently from the standpoint of modern operations.

"It is old and maintenance is a serious and costly item and if the Founder Societies are to serve the growing membership effectively there is no doubt that more and better planned space is urgently needed."

Mr. Byrne stated that the Greater New York Business Campaign is now organizing and starting to initiate active solicitation.

Serving as Campaign treasurer is T. J. Shanahan, president of the Federation Bank and Trust Company.

Divisional chairmen in addition to Dandrow are: R. W. Dowling, president, City Investing Company, and S. D. Nostrand, president, Cross & Brown, Inc.

First Joint Conference on Automatic Techniques Held

THE FIRST ANNUAL Joint Conference on Automatic Techniques, sponsored jointly by AIEE, American Society of Mechanical Engineers (ASME), and Institute of Radio Engineers (IRE), was held at the Hotel Statler in Detroit, Mich., on April 14-16, 1958. Intended to be the first of a series to be held annually, the Conference was devoted to a discussion of tools and methods available for introducing automatic techniques in manufacturing industries, process industries, engineering computations, and operational data handling.

Preparation of the Conference lay in the hands of a Steering Committee, representing the sponsoring societies, and consisting of M. Bradner, ASME, The Foxboro Co.; I. S. Coggeshall, AIEE, IRE, Western Union Telegraph Co.; J. E. Eiselein, IRE, Radio Corporation of America; R. S. Gardner, AIEE, assistant secretary, Technical Committee Activities; and G. W. Heumann, AIEE, General Electric Co.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Joint general co-chairmen of the Conference were T. H. Belcher, Michigan Bell Telephone Co., and G. W. Heumann. The Technical Program Committee, under the chairmanship of W. R. Harris, Westinghouse Electric Corporation, consisted of G. W. Knapp, General Electric Company; C. A. Priest, Onondaga Pottery Co.; A. R. Satullo, Satullo Co.; and F. D. Snyder, Westinghouse Electric Corporation. Publicity was in the hands of R. M. H. Berg, *Control Engineering*, assisted by B. Toorongian, Detroit Edison Co.

J. W. Eakins, J. W. Eakins Co., acted as Conference treasurer. In making the local arrangements, T. H. Belcher was assisted by a committee consisting of H. R. Armstrong, Detroit Edison Co.; L. Augustus, Michigan Bell Telephone Co.; K. Bodger, Ford Motor Co.; A. L. Coates, Michigan Bell Telephone Co.; R. Gasparsky, Udylite Co.; C. M. Hannum, A. J. Brandt Co.; E. J. Love, Station WWJ, Detroit; P. A. Rabideau, Westinghouse Electric Corporation; N. D. Saigeon, Ford Motor Co.

The morning session on Monday, April 14, chairmanned by W. R. Harris, was devoted to a discussion of automatic techniques in the manufacturing industries. G. W. Heumann reviewed the joint effort of the sponsoring societies and stated that the Conference was intended to provide a forum at which designers of industrial equipment might lay before the users' engineers, the tools and techniques which have become available, and users' engineers would tell about their problems, needs, and experiences.

C. M. Rhoades, General Electric Company, presented a paper (CP58-583) "Numerical Control Proves Itself in Production," in which he described briefly a number of production machines on which numerical positioning control has been used successfully, such as turret punch press, drilling machine, lathe, turret drill press, resistance welding machine, coil winding machine, reversing steel roughing mill, and conductor milling machine.

A paper by F. C. Brammer, International Business Machine Corporation, (CP58-584) "Semiautomatic Circuit Component Tester," describes a testing equipment which, through a semiautomatic testing procedure, ascertains defects in components of printed circuit cards and their tolerances without removing them from their circuits.

E. H. Browning, Westinghouse Electric Corporation, gave a paper (CP58-585) "Advanced Automatic Controls Applied to Metal Rolling and Processing Electric Drive Systems" in which various automatic operations in steel making are described.

During luncheon, H. Bumpas, Michigan

Bell Telephone Co., presented a very effective demonstration of stereophonic sound from binaural recordings.

The afternoon session, presided over by G. W. Knapp, was devoted to automatic techniques in the process industries. J. P. Laird, E. I. du Pont de Nemours & Co., (Inc.) in his paper (58-AUT-5) "Logical Development of the Design for Sequential Control of Chemical Batch Processes," developed a system of "logic" representation of electric circuits based on Boolean algebra.

W. G. Deutsch, Panellit, Inc., in his paper (CP58-586) "Application of Automatic Techniques in the Handling of Physical Data for a Modern Refinery," discussed the fact that, even with the best automatic control systems, men are required to make decisions which are beyond the capabilities of machines.

G. E. Hindley, Reliance Electric and Engineering Co., presented "Application of Automation Techniques to Closed Loop Process Systems" which describes various automatic control techniques applied to adjustable-voltage control systems.

The morning session on Tuesday, April 15, chairmanned by F. D. Snyder, was devoted to automatic techniques in engineering computations. J. T. Olsztyn's (General Motors Corp.) paper (58-AUT-1) "The Application of Computers to Automotive Design and System Studies" presented case histories of how electronic digital techniques, using an IBM *704* computer, results in substantial savings in engineering time for solving complex mechanical design problems.

R. W. Ferguson, Westinghouse Electric Corporation, in his paper (CP58-588) "Automatic Engineering through Computers" describes the IBM digital *704* computer, and the passive element and electronic analog computers which are used in the analytical department of Westinghouse at East Pittsburgh.

"Automation in Highway Design" (CP58-589) was the subject of J. M. Cahn, Benson Lehner Corp. The author describes the various steps which the highway engineer takes in establishing the route of a highway, considering topography, land values, and traffic requirements.

V. Paschkis, Columbia University, in his paper (58-AUT-4) "Automatic Techniques, Large Computers, and Engineering Calculations," stated that before automating an industrial process, a careful study should be made of the variables affecting the process, to reduce the "art" element and increase the "science" element.

During luncheon, S. H. Shennhan, news commentator of station WJR, gave a talk on the use of automatic data transmission systems used in the preparation of recordings for news broadcasts.

I. S. Coggeshall acted as chairman of the afternoon session dealing with automatic techniques in operational data handling. The first paper (58-AUT-3) "A Survey of the Application of Automatic Devices for Electric Power Generation," by A. C. Hartranft and F. H. Light, Philadelphia Electric Co., described the methods used by the Philadelphia Electric Co. to control flow of power in their system.

C. Pilnick, Consolidated Avionics Corp., presented a paper (CP58-591) "Automatic Job Control Data System" describing a system for producing the intraplant paperwork necessary for payroll preparation, cost accounting, and compilation of statistics for job planning.

Spencer Photographers

COMMITTEE MEMBERS and banquet guest speaker at Detroit Joint Conference on Automatic Techniques include: (*left to right, front row*) T. H. Belcher, co-chairman; Magnus von Braun, guest speaker; G. W. Heumann, co-chairman; (*back row*) A. R. Satullo, Program Committee; J. W. Eakins, treasurer; G. W. Knapp, Program Committee; F. D. Snyder, Program Committee; J. E. Eiselein, Steering Committee; I. S. Coggeshall, Steering Committee.

W. F. Gregory and W. J. Walsh, Western Union Telegraph Co., presented a paper (CP58-592) "A Nation-wide System for Automatic Processing of Business Data," which describes a system used by the Western Union Telegraph Co. for centralized handling of payroll and cost data by means of integrated data processing through common language tape.

At the banquet held Tuesday evening, the guest speaker was Magnus von Braun, manager, Redstone Program Control, Chrysler Corp. He recalled his experiences when he and fellow scientists of the German rocket development station at Peenemuende were captured by United States troops in 1945 and brought to the United States. He stated that the Soviets captured the German rocket manufacturing facilities, with drawings and the engineering staff. The USSR immediately engaged in intensive missile development work and obtained a headstart over the United States. Mr. Von Braun, in speaking of educational problems, stressed the importance of teaching logic, reasoning, and thinking, rather than mere facts. "American education teaches know-how, European education teaches know-why," he stated.

The morning session on Wednesday, April 16, was devoted to a panel discussion on the status of the tools of automatic techniques. Chairman and moderator was L. F. Lewis, General Electric Company. In his introductory paper (CP58-600) "The Tools of Automatic Production," he stressed that automatic production has resulted primarily from the systematic study of the potential of existing equipment and the application of "know how."

H. W. Mergler, Case Institute of Technology, in his paper (CP58-593) "The Limiting Influence of Available Control Components on Numerical Machine Tool Control Designs," stated that for optimizing control design, greater knowledge is required of machine tool parts, masses, tolerances, accessories, to fit them properly into feedback control theory.

W. M. Young, Richardson Scale Co., in his paper (58-AUT-7) "The Application of the Punch Card to Automatic Weighing of Bulk Materials," describes a system of programming automatic scaling of materials to be blended.

G. Revesz, Robertshaw-Fulton Control Co., presented a paper (CP58-594) "Process Instrumentation for the Measurement and Control of Level," which discusses capacitance-type measuring methods for indicating the level of liquid, granular, or powdery materials.

J. W. Hopper, Pratt and Whitney Co., in his paper (58-AUT-6) "Basic Gauges and Gaging Considerations for Automatic Machine Control," stresses the need for automatic gaging while material is in process, and the need for having the machine adjust automatically to desired dimensions.

The final paper by R. G. Spencer, Vickers, Inc. (58-AUT-2) "Industrial Servo Valve Applications," discusses reliability and performance of hydraulic servo valves.

At the end of the panel presentation, a moving picture was shown entitled "Automation and Mr. Halstead." An institutional picture which is part of the "More Power for America" series sponsored by the General Electric Company, it points up opportunities for automating high-production as well as low-production operations.

The Conference was concluded with a

luncheon and a tour of the Dearborn Engine Plant of the Ford Motor Co.

The 1959 Joint Conference on Automatic Techniques will be held in Chicago, Ill., in May. It will be sponsored by AIEE, ASME, and IRE.

Preprints of most papers presented at the Detroit Conference can be obtained from AIEE or ASME headquarters. Members of AIEE, ASME, and IRE are entitled to receive copies of all papers at the regular member price.

The following papers can be obtained by writing to American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y. The member price is 40¢, the nonmember price 80¢ per copy: CP58-583, C. M. Rhoades; CP58-584, F. C. Brammer; CP58-585, E. H. Browning; CP58-586, W. G. Deutsch; CP58-588, R. W. Ferguson; CP58-589, J. M. Cahn; CP58-591, C. Pilnik; CP58-592, W. F. Gregory and W. J. Walsh; CP58-593, H. W. Mergler; CP58-594, G. Revesz; CP58-600, L. F. Lewis.

The following papers can be obtained by writing to the American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y. The member price is 25¢, the non-member price 50¢ per copy: 58-AUT-1, J. T. Olsztyn; 58-AUT-2, R. G. Spencer; 58-AUT-3, A. C. Hartranft and F. H. Light; 58-AUT-4, V. Paschkis; 58-AUT-5, J. P. Laird; 58-AUT-6, J. W. Hopper; 58-AUT-7, W. M. Young.

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33 West 39th Street,
New York 18, N.Y.

AIEE Pacific General Meeting Will Be Held in Sacramento, Calif.

THE AIEE Pacific General Meeting will be held in Sacramento, Calif., August 19-22, 1958. The excellent technical, social, and entertainment program—combined with the natural geographic and climatic advantages of the area—are such as to encourage AIEE members to combine a business trip to the convention with a family vacation.

Sacramento is the gateway to numerous points of interest such as San Francisco, Squaw Valley (site of the 1960 Winter Olympics), Reno, Yosemite Park, etc. Sacramento is served by United Air Lines, which has several flights daily from almost all locations. The Southern Pacific Railway Company and the Western Pacific Railways both serve Sacramento directly. The Santa Fe stops at Stockton, a nearby town to the south and persons may continue their trip to Sacramento by bus, rail, or airline. The major highways U.S. 40, 50, and 99 all meet in Sacramento.

Headquarters for the Convention will be the Senator Hotel.

General Session

The opening session will be held in the Empire Room of the Senator Hotel and will be preceded by a coffee hour held in the Gold Room. At the opening session members will hear an address by Institute President W. J. Barrett and other speakers of national repute. The registration desk will be located in the lobby of the Senator Hotel and facilities will be available Monday evening and throughout the meeting. Advance registrations are encouraged, for the convenience of the members and nonmembers attending.

ELVERTA SUBSTATION is a principal receiving substation of the Sacramento Municipal Utility District at which they take power from the U.S. Bureau of Reclamation at 230 kv. Two 185,000-kva 3-phase transformers supply two 115-kv lines and six 69-kv outgoing circuits. The Substation will be visited during one of the inspection trips planned for the Pacific General Meeting of AIEE.

Inspection Trips

The inspection trip plans are outstanding. Provisions have been made to visit electrical facilities at: one of the world's largest rocket plants, Aerojet-General (they produce the 2nd stage of Vanguard, the Aerobee, etc.); Procter and Gamble; two large utility 230-kv receiving substations; the new Folsom Dam and switchyards (including a special AIEE ceremony dedicating the original Folsom Powerhouse—first energized in 1895—as a historical monument); the huge U.S. Air Defense and Air Material Command at the McClellan Air Force Base, and the Army Signal Depot.

Entertainment

Fine entertainment and family fun is planned for all who attend the meeting. Wives and children are welcome. Provisions may be made for baby sitting and child care. Various forms of recreation are available for children and youth of all ages. Outstanding features of the entertainment program will be a Wine Tasting Festival and an authentic Hawaiian Luau.

The Wine Tasting Festival is a unique party during which ample quantities of various types of California's world-famous wines are provided for sampling. There will be no charge for this event.

The Luau will feature dancing and food served under the stars. The menu will be Suckling Pig, Lau-lau Chicken, Poi, Terriaki Beef, Tahitian Rum Melon, etc., served by Hula girls and beach boys—all to the accompaniment of a Hawaiian band replete with Hula dancers. Dancing until midnight to the American music of Clyde Mitchell and his orchestra will follow.

At the Music Circus, 200 tickets, which will be sold on a first-come first-served basis, have been reserved for the stage production of "Most Happy Fella." Held outdoors under a gala circus tent, this novel theatre-in-the-round presentation will fascinate both the men and the women.

All events will be modestly priced.

Ladies Program

In addition to social and entertainment activities previously mentioned, many spe-

cial plans have been made for visiting ladies. These include coffee and hospitality hours each day, a tour through the mansion of California's Governor, a brunch followed by a poolside fashion show, a special luncheon, a "Tea" at the famous Crocker Art Gallery, and a ladies tour of the Tide and Oxydol Plant of Procter and Gamble.

Student Activities

There will be a special students' and counselors' luncheon. Time for discussions of mutual interest will be allowed following the meeting. Students will not be charged for the luncheon or for inspection trips they wish to take.

Sports and Recreation

Plans for a Golf Tournament at the Haggin Oaks Golf Course are well under way. The Elks Temple recreation facilities will be available to guests attending the meeting. Facilities are also available for tennis and handball. With swimming pools available at most of the motels, an interesting sports calender is in prospect.

PG&E News Bureau

EXTERIOR VIEW of the old Folsom Power House which will be dedicated as a historical monument during the AIEE Pacific General Meeting. This hydroelectric plant, first energized in 1895, generated power for 57 years and was one of the nation's first 3-phase a-c power plants.

Pittsburgh Will Be Host to Fall General Meeting of AIEE

FROM OCTOBER 26 to 31, 1958, Pittsburgh, Pa., will play host to the Fall General Meeting of the Institute. Headquarters for the meeting will be the Penn-Sheraton Hotel located across from Mellon Square in the heart of the Golden Triangle. The local committee, under the chairmanship of A. A. Johnson of Westinghouse Electric Corporation, has chosen as the slogan for the meeting, "Research—Gateway to the Future."

Visitors to Pittsburgh will see the results of the redevelopment of this the Rennaissance City of America, around Mellon Square, in the Gateway Center, and in the Oakland district.

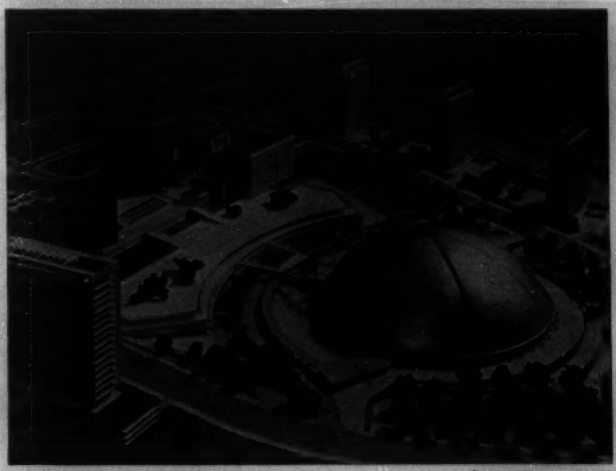
Preliminary work is now in progress on the combination Civic Auditorium—Sports Arena which will be located in the Lower Hill district at the eastern end of the Golden Triangle. A unique feature of this is the retractable roof of the arena which will pivot like a Spanish fan, permitting a starlight setting for the Civic Light Opera and other outdoor events when the weather is good, and folding quickly into a weathertight dome when it rains. A mobile floor arrangement will permit 8,500 spectators for operettas, 12,000 for hockey, ice shows, circuses, and rodeos, and up to 16,750 for boxing and conventions. Completion of the Civic Auditorium-Sports Arena is expected in 1959.

A timely and outstanding inspection trip during this meeting will be to the Shippingport Atomic Power Station, one of the world's first full-scale electric power plants devoted exclusively to peacetime needs utilizing an atomic reactor as its primary heat source. This station represents a significant milestone in nuclear power progress. Westinghouse Electric Corporation designed and built the nuclear reactor under contract with the U. S. Atomic Energy Commission. Duquesne Light Company of Pittsburgh built the electric generating portion of the plant and is operating the entire facility.

Since the plant first went into commercial operation on December 18, 1957, the plant has undergone a series of tests to determine the parameters and capabilities of this atomic heat source.

While experimental reactors of many different types have been built on a small scale, the technology of the pressurized water reactor—the same type used on the submarine *USS Nautilus*—is by far the most advanced.

Despite the fact that this was a pioneering venture, this plant, like any other



Courtesy Newman Schmidt

MODEL of the combination Civic Auditorium–Sports Arena to be erected in Pittsburgh, Pa., the city which will be host to the Fall General Meeting of the Institute, October 26 to 31, 1958. A unique feature of this structure, which is expected to be completed in 1959, is the retractable roof of the Arena which will pivot like a Spanish fan, permitting a starlight setting for the Civic Light Opera and other outdoor events when the weather is good, and folding quickly into a weathertight dome when it rains.

generating station, was designed to fit into the Duquesne Light Company system. At present, the plant has a net output in excess of 60,000 kw at 600 pounds steam pressure. The reactor is cooled by purified water at 2,000 pounds per square inch absolute pressure. The first core was designed to last 3,000 hours at 60,000 kw of net generation. A second core is presently being designed which will enable the generating plant to realize its rated capacity of 100,000 kw.

EUSEC Meets in New York, April 28-May 2

FOR THE FIRST TIME, a conference of representatives of Engineering Societies of Western Europe and the United States (EUSEC) convened in America. The Sixth Conference of EUSEC was held at the Hotel Roosevelt in New York, N. Y., April 28–May 2, with 45 delegates representing 23 engineering societies in 14 countries attending.

Following several years of preliminary ground work, the three British Engineering Institutions in 1948 invited the presidents and secretaries of the national engineering societies of Europe and the United States to meet together in London to determine ways in which their organizations could co-operate in furthering the purposes of their organization. The meeting in October 1948 was a success, and paved the way to a second meeting, again held in London, in September 1949, at which a constitution and operating procedure were agreed upon. Since then conferences have been held in The Hague (1951), Paris (1953), and Copenhagen (1955).

In a warm welcome to the delegates attending the Sixth Conference, American Society of Civil Engineers (ASCE) President L. R. Howson said: "History has proved that engineering never has known boundaries. Our profession is such that our skills should not and, indeed, cannot be confined to one community, state, or nation. Members of the five American societies, which I represent here, are today working all over the world. The same is true of the societies and councils you represent in European countries. If there were boundaries, we would not be meeting here today. In fact, there would be no EUSEC. I am sure you will find American engineers as enthusiastic and energetic about EUSEC as their visitors from abroad. I welcome you to the United States and to the Sixth General Assembly of EUSEC."

Engineering education and training have been given the most active attention by EUSEC since its inception. Three assemblies have devoted attention to these important subjects. The Proceedings of the Third EUSEC Conference on Engineering Education, held in Paris in September 1957, are in print with special appendixes covering practices in Belgium, the United States, and the United Kingdom. In the *Proceedings* are reports from, and appraisals of, the methods followed in the participating countries. The subjects covered include: (1) a glossary of terms used in engineering education and training, (2) general education before admission to the university, (3) selection for admission to the engineering school, (4) education in the schools and universities, (5) postgraduate education and training, (6) practical training of the engineer, and (7) criteria for professional recognition.

Other important topics given continuous consideration by EUSEC are: (1) abstracting and classifying engineering literature, (2) defining the terms "professional engineer" and "engineering technician," (3) fostering and facilitating the exchange of lecturers, (4) establishing reciprocal arrangements for extending professional courtesies to society members of one country visiting the country of another society, and (5) reporting on the supply of and demand for engineers, so that they may be utilized to their fullest capacity. All these subjects were on the New York Conference agenda.

At the New York Conference, Ove Guldberg, retiring general secretary of EUSEC and secretary of Dansk Ingeniorforening, formally transferred the management responsibilities of EUSEC to the USA societies. W. H. Wisely, executive secretary of ASCE, was named general secretary, and O. B. Shier, secretary of American Society of Mechanical Engineers, became editor of the EUSEC Bulletin. Two engineering societies were admitted to EUSEC: Ordem dos Engenhiros de Portugal and the Instituto de Ingenieros Civiles de Espana and the delegates from these societies were seated and participated in the deliberations of the Conference. W. J. Barrett, AIEE president, presided over the closing session.

An invitation from the Société Royale Belge des Ingenieurs et des Industriels to hold the next conference in Copenhagen was accepted for September 1960 or April 1961, with the exact date to be determined by the Advisory Committee. The committee consists of Paul Bastien, chairman, and W. H. Wisely, Edmond Hianné, Ove Guldberg, A. C. Hartley, and Dr. H. Grunewald.

PARTICIPANTS in the highly productive Sixth EUSEC Conference, New York, included representatives of 23 engineering societies from 14 countries—a fine example of international co-operation.

Ben Moreell Receives Washington Award for 1958

The engineering profession's highest honor, the Washington Award, was presented to Ben Moreell at the Drake Hotel in Chicago, Ill. on May 9, 1958.

The Washington Award is an honor conferred upon an engineer by fellow-engineers for accomplishments which preeminently promote the happiness, comfort, and well-being of humanity. The Award is administered by Western Society of Engineers on recommendation of a commission representing the AIEE, American Society of Civil Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, American Society of Mechanical Engineers, and Western Society of Engineers.

Mr. Moreell, chairman of the board of Jones & Laughlin Steel Corporation, received the Washington Award for ". . . distinguished service as a skilled engineer, outstanding naval officer, industrialist, and Hoover Commission associate."

During his nearly 30 years of naval service, he rose from the ranks to become the only non-Annapolis graduate ever to attain the permanent rank of Admiral. During World War II, Admiral Moreell conceived and brought into being the organization which, though military in nature, devoted its primary energies to construction and engineering problems peculiar to war time. Adm. Moreell's brain-

child became known as the "Sea Bees."

When, after the war, he retired from active service in 1946, Adm. Moreell channeled his great energies into directing one of the United States' major industrial organizations, Jones & Laughlin Steel Corporation where he launched a $5 million expansion program. Coupled with the plant construction in the blighted area of Pittsburgh's south side, Mr. Moreell saw to it that the company, working with the union and the City government, found homes for over 100 families that had to be moved from the area. Ben Moreell, for his many contributions to that city's welfare and progress, was chosen "Pittsburgh Man of the Year" for 1951 by the Pittsburgh Chamber of Commerce.

Dr. J. T. Rettaliata, president of the Illinois Institute of Technology and chairman of the Washington Award Commission presided at the Award Dinner. O. G. Smith, chief engineer at Illinois Bell Telephone Company and president of Western Society of Engineers, presented the Washington Award for 1958 to Mr. Moreell, whose address was entitled "An Engineer Looks at Engineering Education."

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until July 25. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before July 25.

57- 84 **The Effect of Composition on the Oxidation Stability of Electrical Oils.** *J. L. Jezl, A. P. Stuart, E. S. Ross*

58-245 **Power Tests Prove Single-Insulator Isolated-Phase Aluminum Bus.** *A. H. Powell, N. Swerdlow*

58-531 **Electrical Engineering Aspects of the Enrico Fermi Atomic Power Plant.** *R. H. Logue*

58-579 **Electrical Safety in Hospital Operating Rooms.** *N. L. Griffin*

Reprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

Many Timely Papers Presented at AIEE Great Lakes District Meeting

A THREE-DAY MEETING of the Great Lakes District was held in East Lansing, Mich., May 5-7, 1958, with headquarters in the Kellogg Center on the campus of Michigan State University. Some 17 technical sessions including two student sessions, two luncheons, a dinner, and banquet were held during the three days as well as inspection trips, and special activities for the ladies under the chairmanship of Mrs. J. D. Ryder.

General Session

The feature of the General Session was an address, "Missiles and Manpower" by Dr. J. D. Ryder, dean, College of Engineering, Michigan State University. Dr. Ryder explained that the event of last October 4 had not as yet had any affect on us. He stated that the North-South orbit passing over populated areas and the transmission frequency chosen were intended for propaganda purposes and that placing a satellite in orbit was not new. What the event did do was to place us now in an age of space, an age of rockets and missiles. He mentioned several types of missiles and their guiding principles: missiles guided by a radio beam from the ground, and those which seek out heat or employ the principle of inertial guidance used for many years in navigation. However, he stated that stable platform guidance in outer space was not so easy and that this introduced a whole new magnitude of problems. For example, a variation in course of one half of a degree at a speed of 18,000 miles per hour would cause considerable drift in the course of 15 minutes. There is also the problem of retrieval from outer space combined with the acceleration at take-off and the heat generated, which illustrates modern complexity.

The modern bomber, which is 85% electrical, is comprised of 50 miles of wire, a great many vacuum tubes, and 100 kilowatts for the de-icer alone. This is the level at which college graduates step off today.

Dr. Ryder pointed out that, in 1949, there was supposed to be a surplus of engineering graduates; whereas, in 1952, there was a shortage and last August the surplus reappeared again. Guidance people in the high schools were confused and the whole matter of high school students interested in engineering is a complex public relations problem. How easy it is to persuade someone away from a course in mathematics! He stated that the need for intellect should be emphasized to meet the challenge that exists as a result of things becoming more complex. The United States is going to be short of manpower, and out of all the professional engineers only the top 10 or 15% are well qualified. Dr. Ryder was well impressed with technological strides in Japan where, from the first to the sixth grades, 6½ days' time per week is spent in school which is 30%

AT THE OPENING DAY LUNCHEON of the AIEE Great Lakes District Meeting, May 5-7, on the Michigan State University campus, East Lansing, Mich., are: (left to right) W. J. Barrett, AIEE president; G. Mennen Williams, governor of the State of Michigan who gave a welcoming address at the luncheon; and J. H. Foote, AIEE vice-president from the Great Lakes District No. 5.

more than in this country. The technical equipment in Japan is really first class and, in the assembly of a transistor, their fingers have a 7:1 advantage. The challenge will be met with quality.

In this country, the grade schools and high schools cannot get qualified teachers at existing salary levels. A 1955 survey taken in 30 states indicated 1,800 positions for teachers of science and mathematics with only 1,020 applicants available; whereas, in the field of social sciences, there was a surplus of 110 applicants. The results of this deficiency show up in the entering freshman classes.

The shotgun approach in recent years has attracted 1,000 ill-prepared students a year with a much higher percentage of drop outs in the last two years. Of the entrants, 25% have not taken sufficient mathematics and, after a few weeks, 10 or 15% of these drop out, and at the end of the year 30%.

To meet the challenge, Dr. Ryder told of a new experiment in education in which past mistakes would not be repeated. The first class would enter in 1959, but one degree would be given, and there was no need for departments. Subject matter would be grouped in areas and all curricula would be based on 3½ years of mathematics. Statistics in the study of heat would not be overlooked. It was hoped that it would present a challenge to the students to work beyond their capacity. On top of all this there would be a graduate school. Dr. Ryder pointed out that, after the war, came the robbing of the campuses by industry and he had a list of 21 schools looking for deans. All this must be accomplished with a shortage of facilities and a shortage of staff. He believed that mathematics was the key to scientific progress.

President Barrett's Remarks

President Barrett explained that this was a period of great importance in the history of the Institute. He stated that studies were under way of growth in the field and the expansion of the Institute to keep pace with the growth of the industry was no easy task. More staff is needed but there is no space for them. One task force is studying the rearrangement of the Technical Committee structure. Anticipating expansion of space in the new building, another task force is busy writing job specifications and putting a price tag on the positions. The Institute is not standing still but planning to operate in 1958 fashion.

Vice-President J. H. Foote, who presided, introduced the guests and speakers. He paid tribute to the 14 Branches represented at the meeting and the excellent quality of the student papers which were presented.

Monday Luncheon

A warm welcome with sincere best wishes for the success of the meeting was given by the Hon. G. Mennen Williams, governor of Michigan. The Governor outlined the geographical, industrial, and agricultural position of Michigan, which manufactures most of the world's automobiles. The State is interested in foreign trade and is nearer by water to London, Stockholm, and Antwerp than New New York is. It is second in production of iron ore and the Detroit River locks at Sioux carry more tonnage than the Suez and Panama Canals combined.

A Scientific Tour of Soviet Russia

Some technical and general information illustrated with lantern slides from a recent trip through the Soviet Union was given by W. C. Dunlap, Jr. Five important solid-state research laboratories were visited. At the Institute of Semiconductors, Dr. Joffe, one of the most distinguished of Soviet scientists most famous for his work dealing with the Peltier effect, was interviewed. With new materials recently developed, Dr. Joffe explained that they can cool a junction by 90–100 C. About 15 different applications were seen including an apartment size refrigerator without any moving parts. After visits to other laboratories, including the Kiev Institute of Physics, Dr. Dunlap concluded that he was impressed by the general program, the class of equipment, and the caliber of the people, but that the work seemed several years behind that of our leading laboratories. Belief was expressed that the Soviets are thinking ahead of us on the basic theory of solid-state and of semiconductor materials and devices. In general, the Russians seemed well pleased with their way of life and they have more of an attraction and admiration for things American than the opposite.

Howard Hess, chairman of the Michigan Section, presided during the luncheon and introduced the speakers.

Technical Sessions

Many timely papers were presented in the 15 technical sessions held during the 3-day meeting. In the field of power transmission, with loads increasing and rights of way becoming more difficult to obtain, there were papers dealing with tests on bundle conductors and twin conductor arrangements as well as higher voltage transmission, 345-kv vs 138-kv, and consumers power probes 345-kv. Other papers dealt with such problems as the 46-kv submarine cable crossing the Straits of Mackinac. In the field of substations and equipment, there were papers on the advantages of the modular structural member design, the placement of lightning arresters, the advantages of the double-bus arrangement, and studies of steel transformer enclosure for noise attenuation.

In a session on nuclear developments, 90% of the subject matter dealt with nuclear power reactors. System conditions, essential for supply from a nuclear power reactor, such as transient stability limits and no sudden voltage fluctuations, were brought out in a paper on auxiliary power design considerations for a nuclear power plant. Instrumentation for reactor control and design and development of a simulator for control system studies were the subjects of other papers. Also described were the electrical engineering aspects of the Enrico Fermi Atomic Power Plant and the design of a pile oscillator for the Ford Nuclear Reactor. Other sessions of interest to power people dealt with the changing trends in education and challenges in the power field as well as a session on applications of analog and digital computers.

Communications and Electronics

In two sessions on communications, a variety of subject matter was presented which had to do with railroad communications, special telephone services in metropolitan areas, and the application of automatic timing and ticketing of toll calls. The Florida–Cuba over-the-horizon system was described as well as a public air–ground telephone service and the operation of several types of carrier. In a session on electronics, there were papers on increasing the effective dynamic range of radar and a panoramic receiver simulator.

Industrial Sessions

In four industrial sessions, it was only natural that a number of papers were in the field of the automotive industry; for example, there were discussions of static and proximity control, induction and dielectric heating, the electrical circuitry of noise and vibration in a dynamometer, optics for auto lighting, and design considerations of an engine generator unit for utility trucks. With the space age approaching, as pointed out by Dr. Ryder, a very timely paper gave a qualitative description of inertial guidance principles. This was presented by C. F. Vondra of the A-C Spark Plug Division of the General Motors Corporation.

Student Sessions and Prize Paper Contest

Some 14 technical papers were presented by students from as many different Branches within the District. Everyone was impressed with the excellent quality of the presentations and the subject matter. Again referring to the space age, one of the papers dealt with the tracking of satellites; another discussed Kepler's method of determining the true orbit of the earth; still another was on inertial guidance. There was also a paper on nuclear batteries and energy conversion. The meeting was opened by Prof. J. D. Dixon, chairman, District No. 5 Committee on Student Activities. John Drabelle, vice-chairman, Michigan State University Branch; Ray Wentworth, chairman, North Dakota University Branch; and Richard Sprague, chairman, Michigan State University Branch, presided over the sessions. Following is the list of the student papers presented:

1. "Analysis of a Control System Using Linear Graph Theory." J. C. Eidson, Michigan State University.
2. "The Radio Interferometer and Its Use in Tracking Satellites." R. J. Loos, University of Illinois.
3. "A Little about D-C Transmission." D. J. Patton, State University of Iowa.
4. "An Electronic Phase Meter for Entire Video Range." H. O. Sorensen. Illinois Institute of Technology.
5. "Inertial Guidance." Jack Herrlin, University of Minnesota.
6. "Energy Conversion—Greatest Challenge Ever To Face Electrical Engineers." H. E. Fiala, North Dakota Agricultural College.

7. "Coincident-Current and Coincident-Flux Magnetic Storage Systems." J. R. Sonner, Rose Polytechnic Institute.

8. "Matrix Analysis of Electric Networks." D. A. Miller, Northwestern University.

9. "Nuclear Batteries." R. F. Green, Marquette University.

10. "Phase-Locked Oscillator Systems as Applied to Double Sideband Suppressed Carrier Communications." Paul Scheibe, University of North Dakota.

11. "An Electronic Random Number Generator." J. A. Lauder, University of Michigan.

12. "Kepler's Method of Determining the True Orbit of the Earth." R. T. Lawson, Milwaukee School of Engineering.

13. "Moving Target Indication." G. D. Breen, University of Notre Dame.

14. "An Automatic Switching Circuit for a Sweep Generator." H. L. Weed, University of Detroit.

STUDENT WINNER and his counselor: John Lauder (left) senior, studying electrical engineering at the University of Michigan, Ann Arbor, Mich., shakes hands with his counselor, J. G. Tarboux, professor of electrical engineering, after winning first place in the Student Paper Competition during the AIEE Great Lakes District Meeting.

Tuesday Luncheon

At a luncheon on Tuesday, the winners of the student prize paper contest were announced and Vice-President Foote made the presentations.

First Prize, consisting of a certificate, $25, a trip to the Summer General Meeting with expenses paid, and a miniature plaque, was won by J. A. Lauder.

Second Prize, consisting of a certificate, $25, and a miniature plaque, went to R. F. Green.

Third Prize, consisting of a certificate, $15, and a miniature plaque, was won by Paul Scheibe.

Honorable mentions were awarded to R. J. Loos, H. O. Sorensen, J. R. Sonner, and R. T. Lawson.

Prof. Dixon commented briefly on the contest and paid tribute to the judges who were as follows: for the written presentation, E. C. Carlson, Illinois Bell Telephone Company; D. W. Angland, North Eastern States Power Company; and F. E. Sanford, Commonwealth Associates; for the oral presentation, Richard Calkins, Pennsylvania Salt Manufacturing Company; Dr. I. Molnar, General Telephone Laboratories, Inc.; and W. B. Middleton, Michigan Bell Telephone Company. The feature of the luncheon was an address on research and development planning by Dr. I. Travis, vice-president, Burroughs Corp. Before deciding on the production and marketing of new products, Dr. Travis analyzed several corporate policies that should be decided before a research and development program can be undertaken. He stated that long-range research decisions could be made within the area of research itself, which is broken down into technological area research and functional research. Around the turn of the century, not enough attention was paid to the tailoring of research and development programs to the corporate needs. For example, in 1907, there was a 40 million market for the Wellsbach gas mantle which became obsolete because of the introduction of electric lamps.

Banquet

A cordial welcome was extended by Dr. T. Hamilton, vice-president of Academic Affairs. He explained that the Kellogg Center was dedicated to education as a life-long affair and that the responsibility was to continue education for adults as long as they live. He was delighted to have adult groups come to the Center and trusted that those attending the meeting would have a greater insight into the problems of today and take away an inspiration.

The keynote address, "Problems Involved in the Education of Engineers" was given by J. H. Campbell, senior vice-president, Consumers Power Company. Speaking from the background of an engineer and a business man as well, Mr. Campbell laid great stress on the need of the engineer to be able to articulate and communicate ideas readily. Engineers must be organizers and leaders of men. He referred to a survey by Dean Hawkins of Purdue University, which asked graduates to rank 26 goals in their order of importance. The results indicated the seven top goals related almost exclusively to the expression of ideas. He advocated the liberal education of engineers in a 5-year course, and stated that the dangers of too narrow an approach in engineering education has somewhat exceeded that in the other professions. The trend toward increased stress on fundamentals with a liberal approach and the avoidance of specialization was considered by Mr. Campbell to be very much in order. The question was also raised as to whether industry was prepared to finish off the specialization training. College faculties are best equipped to do the job of motivation and create the desire in people to attain an intellectual standard.

Dr. J. A. Strelzoff of Michigan State University presided. J. H. Campbell was introduced by Vice-President Foote and musical selections were rendered by the wind ensemble comprised of a number of

Fellow Diploma Presented

F. T. BEAR (left), Delaware Power & Light Company vice-president in charge of engineering, accepts AIEE Fellow Diploma from Dr. B. R. Teare, Jr. (right), dean of engineering and science, Carnegie Institute of Technology, and vice-president AIEE District No. 2. Mr. Bear is only the second person to receive the title of "Fellow" in the Delaware Bay Section of AIEE.

Photo by Willard Stewart, Inc.

students from the different colleges at Michigan State University.

Ladies Activities

After a coffee hour for the ladies each morning, tours were made of the campus by bus with free time for shopping in the nearby campus shops. A luncheon–bridge at the Walnut Hills Country Club and attendance at the banquet Tuesday evening, were events on their schedule. The program was different and relaxing within beautiful surroundings of the Michigan State University campus.

Inspection Trips

Campus tours by bus were arranged on Monday and Tuesday as well as a trip to the television station WJIM-TV, which uses the latest high power televising techniques. On Tuesday, a trip was taken to the Oldsmobile Division of General Motors.

Committees

Members of the Great Lakes District Meeting Committee who made the arrangements were: General Chairman, J. A. Strelzoff; technical program, M. Westrate; ladies activities, Mrs. J. D. Ryder; inspection trips, M. B. Rann; finance, A. W. Rauth; dinners, K. Norris; speakers, T. W. Culpepper; registration, B. K. Osborn; transportation, H. G. Hedges; hotel, W. C. Peterson; student activities, M. A. Melehy; contact, W. R. Carlyon; publicity, J. J. Fredrickson.

ASEE Reports on Engineering Enrollment and Faculty Requirements

THE HEADS of the nation's engineering colleges predict that the mounting requirements for engineers in the next decade will not be met unless American education is prepared to pay the price of attracting top talent into engineering teaching careers.

By 1967, American engineering colleges will need 7,000 more engineering teachers, to bring the total of their engineering faculties to 16,000.

Their salaries should average $12,500 in 1967 dollars, 105% more than today's average.

The total salary bill should be $200 million, an increase of 233%.

The quality of America's technological education in the next 10 years depends critically upon meeting these needs.

These are the conclusions of a 2-year study of what its authors call "the crisis in technological education," sponsored by a special Committee on Development of Engineering Faculties of the American Society for Engineering Education (ASEE).

The conclusions are based on estimates by the heads of the nation's engineering colleges: by 1966-67, undergraduate engineering enrollment will be up 66% and graduate enrollment will have doubled. Already, say the engineering deans, across-the-board salary increases averaging at least 40% are needed to make academic jobs competitive in total satisfactions with nonteaching opportunities. If general salary levels continue to rise, more increases will be needed to keep pace.

The report was released recently by members of ASEE's Committee on Development of Engineering Faculties. The findings, said Dr. H. L. Hazen, dean of the Graduate School at the Massachusetts Institute of Technology (MIT) and chairman of ASEE's committee, present an urgent challenge: Can American education pay the price necessary to attract top talent into engineering teaching careers?

New facilities are important; more efficient use of present facilities and teachers will help; helping students finance their education is also important. "But," Dean Hazen said, "these things are meaningless if students in the future find as teachers only what is left after the cream of the ability has been skimmed.

"The central problem, controlling in an absolute sense, is adequate financing of the faculties," he said.

"Faced with this extremely serious problem of financing the faculty costs of engineering education in the decade ahead, our engineering educators fear most deeply of all the forced deterioration in quality inevitable when expedient rather than first-choice appointments are the pattern," Dean Hazen declared.

To be considered qualified as teachers, most engineering faculty members must have doctor's degrees. The recent output of engineering doctorates, said the committee, is about 600 per year; even all of them could provide only two thirds of the need for new teachers each year for the next decade.

But 90% of these doctorates normally go into industry. "We must find the means," said Dean Hazen, "to make careers in scientific and engineering education genuinely attractive to such first-rate minds as these."

The study on which the ASEE committee bases its conclusions was made by the Bureau of Business and Economic Research at Northeastern University, Boston, Mass., under the direction of Dr. W. H. Miernyk, now visiting professor of economics at MIT, and Dr. M. A. Horowitz, associate professor of economics at Northeastern. Financial support was provided by the National Science Foundation, with added grants from the Burroughs Foundation, the Leeds and Northrup Foundation, the Philco Corporation, and the International Resistor Corporation.

The ASEE committee has had close cooperation with the President's Committee on Scientists and Engineers.

The report estimates that by 1966-67 growing engineering enrollments will add 165,000 more undergraduates to the present 250,000 and will double the present graduate student enrollment of 25,000.

To teach these students adequately, according to the report, will require 7,000 more teachers than are now on engineering faculties. But during the next decade 2,700 of today's faculty will leave the teaching profession, and over the next 10 years engineering deans will therefore be looking for nearly 10,000 new teachers.

(These figures—and others in this report—do not include teachers of basic science, mathematics, and the humanities, who carry almost half of the teaching load for engineering students. These teachers are often outside the engineering school itself.)

Both in enrollment and in faculty, publicly supported institutions expect to grow faster than privately supported. In 1956-57, public institutions employed 58% of the nation's total engineering faculties, but they hope to appoint 68% of the new teachers to be added over the next 10 years.

Already, during the last school year, 732 engineering teachers' desks went unused because good teachers were not found, a shortage of about 8%. In addition, engineering deans reported, more than 500 teaching jobs were filled by emergency part-time, temporary, or unsatisfactory personnel. "The shortage, as thus defined," said the report, "is already significant. Subtle, creeping compromise with quality faculty standards is thus already reported by many deans."

The average salary of an engineering teacher of full professorial rank is today about $900 per month. The deans estimate that this should be raised immediately to about $1,350, to make the jobs truly attractive to first-rate teachers.

Instructors earn on the average $487 and should earn $700.

To meet these needs—to make engineering teaching now competitive with other opportunities for well-qualified engineers, considering intangible as well as tangible rewards—would add $24 million to the nation's engineering faculty salary bill.

To add 76% more teachers to today's engineering faculties in the next decade at these recommended salary levels will add $64 million more to the total.

But in the meantime, in accord with past experience, the general level of salaries is expected to rise. To keep pace with this estimated 3% rise in general salary levels each year in the next decade will add $52 million more to the bill.

The final total is $200 million for engineering faculty salaries in 1966-67.

"This total," Dean Hazen admitted, "is startling in terms of past experience. But it appears to this committee to be the only way to achieve this vital goal:

"We must make careers in engineering teaching so attractive that we can appeal to our first-rank graduates of the next decade and at the same time return to our faculties some of the first-ranking engineers who originally chose other fields of the profession—so attractive that we may be sure of our power to compete for the really good teachers, skilled leaders whose wisdom must be multiplied for future generations."

In addition to Dean Hazen, members of the ASEE committee included Prof. R. E. Bolz of Case Institute of Technology, Dr. J. C. Boyce of Illinois Institute of Technology, Dean G. B. Carson of the Ohio State University, Dean W. L. Everitt

of the University of Illinois, Prof. H. A. Foecke of the University of Notre Dame, M. D. Hooven of the Public Service Electric and Gas Company (New Jersey), and Dr. W. C. White of Northeastern University.

Professor Miernyk served as executive director of the project.

The report, "Engineering Enrollment and Faculty Requirements, 1957-67," is available at 25¢ per copy from the Secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill.

Schenectady Section Features Timely Programs

Program emphasis this year in the Schenectady Section of AIEE has been on the space age. "Dawn of the Age of Space Flight" was an illustrated lecture by D. C. Romick, project engineer, Goodyear Aircraft Corp. Subjects covered included physical well being of space travelers, orbital principles, and devices and methods needed to set up and operate a system of space travel.

The Section joined in supporting a National Society of Professional Engineers sponsored talk on "Air Transportation—A Look into the Future" by J. B. Montgomery, former commanding general, Strategic Air Command, and now general manager aircraft gas turbine department, General Electric Company.

"Guidance Requirements of Project Vanguard" was the popular subject of a joint meeting with Union College and Rensselaer Polytechnic Institute Student Branches. The illustrated talk was given and discussion lead by H. F. Eckenroth, electromechanical engineer of The Martin Co., Baltimore, Md., prime contractor for Project Vanguard.

Dr. H. Hurwitz, Jr., manager, Nucleonics and Radiation Section, General Electric Research Laboratory, spoke on "Fusion Power." He described the basic principles of thermonuclear power as now conceived and including: nature of the reaction, energy losses which must be overcome, and the concept of magnetic confinement.

A popular ladies' night dinner meeting featured the topic "The Promise of Youth." Dr. E. M. Ligon, noted psychologist and director of the character research project at Union College, discussed how people can be led to channel emotional energy into more successful social relationships by better communication and new insights into learning skills as young people.

At the ladies' night program, the following new Fellows of the Institute from the Schenectady Section were honored: R. V. Shepherd, H. D. Snively, and H. C. Steiner. At a later time, I. B. Johnson was also honored as a new Fellow.

On the industrial front two notable talks were presented.

"Computers in Continuous Process Control" was the subject of Irving Lefkowitz, staff of Case Institute of Technology. He reviewed the current status of computers in process control including development acvtivities, and outlined some major problems peculiar to the process field, which presently limit computer control applications.

"Trends in Industrial Automation" was covered by J. D. Cooney, associate editor, *Control Engineering*. His theme described the effects of automation upon all industries and upon the engineering profession —particularly emphasizing educational requirements.

Dr. R. E. Halsted, General Electric Research Laboratory, talked on "New Techniques in Information Display." He emphasized some of the newer techniques in

"Electrical Safety Is Applied Intelligence"

A Message from the AIEE Safety Committee

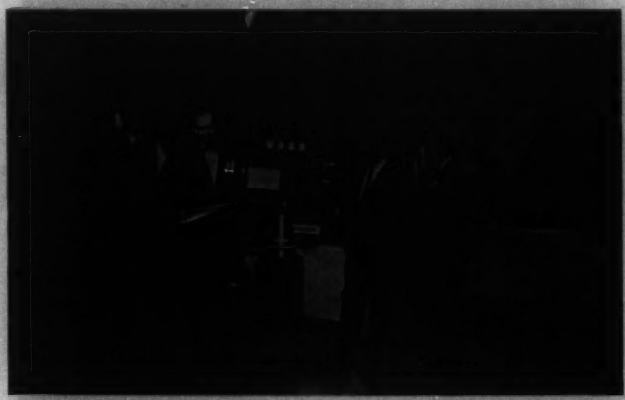
IT IS NOT NECESSARY to be connected with the electrical industry to know that Americans use more electricity, more electrical appliances and equipment than any other nation in the world. This phenomenal growth of power in the home, on the farm, in business and industry, this desire to live and work better electrically, would very likely never have come about, however, without one important factor—the absolute confidence of the American people in all matters electrical. Best proof of this confidence that if it's electrical, it's safe, is the absence of an awareness that an electrical appliance or electrical wiring might have inherent hazards.

This confidence is not accidental. It has been won by a long safety record in the fields of generation, transmission, distribution, and utilization of electrical energy. It is a record of which the electrical industry can be justly proud. Hazards which, naturally, increase in ratio to the growth pattern, have been properly evaluated and provided for so that the safety record has been maintained.

However, the fact that this record is so good can lead to a real danger—complacency. To maintain the present safety record and to assure that there will be no upturn in the future in accident or loss rate, it is necessary for the electrical industry constantly to remind the general public of the need for proper and adequate wiring and for care in the operation of appliances. More important, it will be vital that designers, manufacturers, installers, and operators be subjected to a constant reminder of the necessity of factoring safety into every step of electrical design, manufacture, and utilization.

This is where the AIEE member enters. It is a responsibility of each member to recognize the need for constant vigilance and attention to safety in his own personal field. Those members of AIEE who engage in the preparation and presentation of papers at Section, District, or General Meetings, or Special Technical Conferences can enhance their own profession and further the cause of safety in this country by including coverage of the safety aspects of whatever subject is under discussion whenever safety is at all pertinent. By so doing, we can maintain the excellent safety record even through the coming years that are expected to bring untold strides in the field of electricity.

The Safety Committee, charged by the Institute Bylaws with responsibility for AIEE's consideration of matters relating to the protection of persons and property against hazards associated with electricity and electrical material, urges all individuals, whether in the AIEE or not, to remain vigilant at all times in observance of safety as a personal responsibility to the electrical industry.



INSPECTING television camera equipment during a Schenectady Section inspection trip to studios of WRGB television are: (*left to right*) Gene Matson, H. S. Maxwell, L. Rivest, B. G. Hatch, C. Q. Lemmond, and Prof. H. V. Bibber, Section chairman.

production and use of controlled light, electroluminescence, photoluminescence, light amplifiers, etc.

During an inspection trip, Section members visited the newly constructed complete studio facilities for WGY, WRGB radio-television station.

Michigan Section Announces New Officers

J. W. Eakins of the Jesse W. Eakins Company, Detroit, Mich., has been elected chairman of the Michigan Section, AIEE, for the 1958-59 term. J. J. Fredrickson of the General Electric Company will be the vice-chairman and B. H. Schneider of the Detroit Edison Company will be the secretary-treasurer. Prof. H. M. Hess of Wayne State University, 1957-58 chairman, will now serve as junior past-chairman.

Directors for the 1958-59 term will be R. L. Calkins of the Pennsalt Chemical Corporation, A. C. Fagerlund of Consumers Power Company, C. R. Seibert of Detroit Edison Company, Prof. J. G. Tarboux of the University of Michigan, B. L. Traeger of Michigan Bell Telephone Company, and M. C. Westrate of Commonwealth Associates, Inc.

Indications are that 1958-59 will be another highly productive and active period for the Michigan Section.

International Federation of Automatic Control Starts Work

The International Federation of Automatic Control (IFAC), founded in Paris, France, in September 1957, has now started work. The constitution has so far been ratified by the following 13 national organizations, which have thus become members of IFAC:

Austria—Austrian Working Group for Automation, Austrian Productivity Headquarters

China—Chinese Association of Automation

Czechoslovakia—Laboratory for Automation and Telemechanics of the Czechoslovak Academy of Science

Denmark—The Institution of Danish Civil Engineers

Italy—National Research Council

Japan—National Committee of Automatic Control, Science Council

Norway—The Norwegian Engineering Society

Poland—Polish Committee for Automatics

Roumania—Commission for Automatics, Academy of the Roumanian Democratic Republic

Sweden—Swedish Joint Committee for International Conferences

Switzerland—Swiss Association for Automatics

United States—American Automatic Control Council

USSR—National Committee for Automatic Control

Applications for membership from other national organizations are expected shortly.

Prof. E. Gerecke, Zurich, Switzerland, was nominated treasurer of IFAC (in lieu of Dr. G. Lehmann, Paris, who had withdrawn).

The Executive Council of IFAC as well as the Advisory Group had a meeting in Zurich on March 12-14, with Pres. H. Chestnut (U.S.A.) in the chair. The formation of Technical Committees was agreed on the basis of suggestions made by the Advisory Group, which was presided over by D. P. Eckman (U.S.A.). These Technical Committees will be combined into three main IFAC Committees—on Automatic Control Theory, on Components and Measurements, and on the Application of Automatic Control.

Furthermore, it was proposed to form Technical Committees on Bibliography, on Nomenclature, Symbols, and Definitions, and on Educational Questions. A chairman will be appointed for each of the Committees and the secretariat will be offered to one of the national member organizations.

A draft for the scientific program of the first IFAC Congress for Automatic Control, which is to be held in Moscow, USSR, from June 25 to July 5, 1960, was submitted by the vice-president of IFAC, Prof. A. M. Letov, Moscow, and was approved by the Executive Council after discussion. The manuscripts of papers for the Moscow Congress have to be submitted to the member organizations by Summer 1959.

The first IFAC *Bulletin* is to be issued and distributed shortly by the IFAC Secretary (c/o Verein Deutscher Ingenieure, 79 Prinz-Georg-Strasse, Düsseldorf, Germany) to all member organizations. It will contain information on past and coming events in the field of automatic control all over the world.

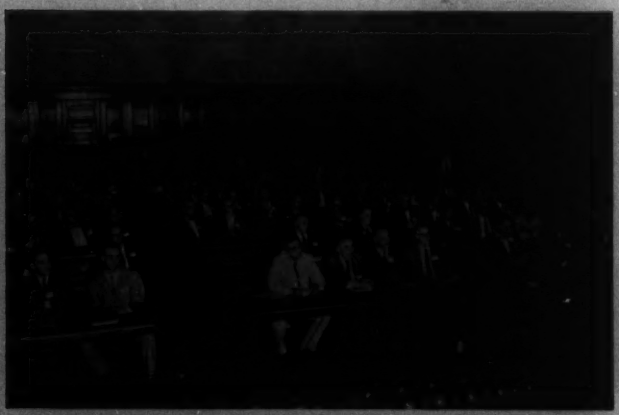
EJC Now Includes 17 Members

The American Institute of Industrial Engineers recently has become a constituent member of Engineers Joint Council (EJC), bringing the total of this class of membership in EJC to 11.

At its April meeting, the Board of Directors of EJC accepted the Louisiana Engineering Society as an affiliate member.

In late 1957, the Western Society of Engineers and the Engineering Societies of New England became affiliate members.

The roster of EJC now includes 11 constituent society members, 2 associate societies, and 4 affiliate societies, a total of 17 members. These members are: Constituents—AIEE, American Society of Civil Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, American Water Works Association, The American Society for Engineering Education, American Society of Heating and Air-Conditioning Engineers, The American Society of Refrigerating Engineers, American Institute of Chemical Engineers, The Society of American Military Engineers, American Institute of Industrial Engineers; Associates—American Society of Agricultural Engineers, American Institute of Consulting Engineers; Affiliates—Los Angeles Council of Engineering Societies, Kentucky Society of Professional Engineers, Western Society of Engineers, and Engineering Societies of New England.



IN SESSION: the Study Group on Industrial and Commercial Power Systems organized by the Cincinnati Section of the Institute.

Study Group Organized by AIEE Cincinnati Section

One of the most successful activities of the AIEE Cincinnati Section this year was the Study Group on Industrial and Commercial Power Systems. The Study Group plan was chosen rather than a Technical Group because the Section Treasury was not able to support an additional series of meetings. By organizing the Study Group, a small fee of $5 for AIEE members and $10 for non-AIEE members could be

charged, which proved sufficient to cover all expenses and add a substantial surplus to the Section treasury.

Total enrollment for the series of 10 weekly meetings was 164 consisting of 42 AIEE members and 122 nonmembers. Average attendance at each meeting was 115 or approximately 70% of enrollment.

The value of the Study Group plan was demonstrated by the fact that 75% of those attending were nonmembers.

AIEE Mississippi Section Sponsors Student Competition

On March 18, the Mississippi State College Branch of AIEE held its annual Student Prize Paper Competition which is sponsored by the Mississippi Section. Three papers were presented in competition for prizes of $50 first prize, $25 second prize, and $10 third prize. The winning paper was entitled "An Introduction to Signal Flow Graphs" by C. N. Causey and R. D. Benton. Second prize was awarded to J. L. Dodd and R. B. Brunson, who presented "Problems of Low Frequency Stimulation." Walter Adams received third prize for his paper entitled "The Digital Computer as Applied to Transient Stability Calculations."

In addition to the prizes provided by the Mississippi Section, the first place winners were awarded a $10 prize by the Institute and a trip to the District Student Paper Conference held at Duke University April 17 and 18, 1958. The second place paper was also to be presented as an additional paper at this Conference. The judging took place at a special meeting at which Vice-President of AIEE District 4, H. W. Oetinger, was a visitor. Judges for the event were J. D. Phillips, Mississippi Power and Light Company; J. E. May, Southern Bell Telephone Company; and F. E. Bates, Southern Bell Telephone Company, all of Jackson, Miss.

Los Angeles Section Holds Student Prize Paper Contest

Four college students, presenting their own technical papers, filled the program of the AIEE Los Angeles Section general meeting held at the University of Southern California (USC) on April 8. Sponsored by the Student Relations Committee, this was the annual student night for the Section. Chairman of the committee is Prof. Fred Bowden, head, electrical department, California State Polytechnic College, San Luis Obispo.

The Section vice-chairman, E. D. Barcus, presided and introduced Jerry Leavitt, program chairman, a senior in the Engineering School, USC, who acted as host.

Richard Duda, senior, University of California at Los Angeles (UCLA), presented some interesting observations to illustrate temperature effects while presenting his paper "Low Frequency Transistor Characteristics."

Wayne Smith, senior, USC, described the physical arrangement of elements and the electrons behavior phenomena of certain electronic tubes in his paper 'Secondary Emmission Amplifier Tubes."

Dave Miley, senior, California Polytechnic, described in theory and by demonstration a magnitude plotter in his paper, "Graphical Solutions of Closed Loop Control Systems."

DISTRICT 4 VICE-PRESIDENT H. W. Oetinger (left) congratulates winners of Mississippi State College Branch Paper Competition R. D. Benton and C. N. Causey. At right is J. R. Burnie, chairman of the Mississippi Section which sponsored the competition.

Allen Hagelberg, senior, California Polytechnic, described the theory of operation and exhibited a model in presenting his paper "One Pole Synchronous Machines."

So well prepared and interesting were all four speakers that it was difficult to separate them for presentation of awards. The prizes were ultimately awarded to

AIEE Rubber and Plastics Subcommittee

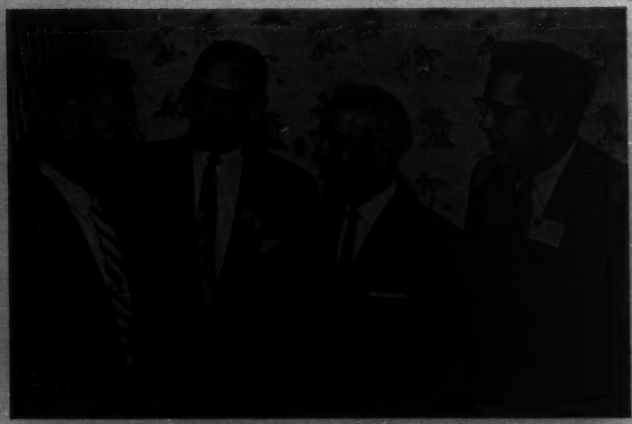
MEMBERS of the AIEE Rubber and Plastics Industries Subcommittee at the Rubber and Plastics Conference held April 14-15, 1958, at the Mayflower Hotel, Akron, Ohio, included: (bottom row, left to right) A. G. Seifried, R. L. Hostetler, K. W. John, Chairman V. S. Sywulka, Vice-Chairman E. L. Smith, Secretary R. D. Heyburn, (middle row, left to right) G. F. Muller, E. F. Johnson, E. W. Wilson, F. E. Palmer, W. J. Goodwin, W. S. Watkins, (top row, left to right) R. P. Bleikamp, F. C. Timberman, E. T. Scholze, L. E. Buess, C. E. Robinson, N. A. Williams, and R. F. Snyder.

Fellow Diploma Presented to G. W. Bean

G. W. BEAN (*left*), chief engineer, Texas Electric Service Company, receives AIEE Fellow Diploma from E. B. Robertson (*right*), past president of the Institute, at a meeting of the AIEE North Texas Section. Principal speaker at the meeting was Abner McCall, dean of Baylor University Law School and former associate justice of the Supreme Court of Texas, whose address was entitled "The Conservative's Concern for His Fellow Man."

Courtesy Fort Worth Star Telegram

AIEE West Michigan Section



OFFICERS of the West Michigan Section of the AIEE and the principal speaker for their dinner meeting at the Grand Rapids Country Club, Grand Rapids, Mich., are: (*left to right*) S. R. VanAntwerp, vice-chairman of the West Michigan Section; W. J. Sundheimer, chairman of the West Michigan Section; J. H. Foote, vice-president of District No. 5, AIEE, and speaker for the evening; and George Raven, secretary-treasurer of the West Michigan Section. This meeting was held jointly with the West Michigan Chapter of the Michigan Society of Professional Engineers. Mr. Foote spoke on the subject of "Russia As I Saw It."

Mr. Duda as first, Mr. Hagelberg second, and Mr. Miley third, with Mr. Smith a very close runner-up.

Among the faculty representatives attending this meeting were the following counsellors: Prof. L. L. Grandi, UCLA; Prof. Warren Anderson, California Polytechnic; Prof. Paul Beroza, acting for Prof. R. C. Lewis of USC.

The meeting was preceeded by inspection tours through the University Electronic Computor Laboratory, Wind Tunnel Laboratory, and new Petroleum and Chemical Engineering Buildings. These tours were arranged by C. J. Smith, senior at USC.

News of the AIEE Marine Transportation Committee

A new edition of AIEE Standard No. *45*, "Recommended Practice for Electrical Installations on Shipboard," will be issued later this year. This 1958 edition will supersede the March 1955 edition and will contain the modifications and additions adopted by the Marine Transportation Committee since the previous issue went to press. This 1958 edition continues the Marine Transportation Committee practice of bringing up-to-date versions of AIEE No. *45* at periodic intervals of about 3 years in order to keep this publication reflecting modern shipboard good practices.

Six members of the Marine Transportation Committee attended the meetings of Technical Committee 18 of the International Electrotechnical Commission (IEC) in Konstanz, Germany, the week of June 2-7. Technical Committee 18 is concerned with the standardization of electrical installations on board ship on a world-wide basis. This series of meetings was concerned primarily with modifications and additions for a second edition of IEC Technical Publication *92*, "Recommendations for Electrical Installations in Ships." The first edition was published in 1957 and was unanimously supported by some 16 countries. The AIEE Marine Transportation Committee is the advisory group to the U. S. National Committee, and as such has represented the United States in four such international conferences since the resumption of these activities in 1954.

UPADI Plans Convention in Montreal, September 2-6

The fifth Convention of the Union Panamericana de Ingenieros (UPADI) will be held in Montreal, Que., Canada, September 2-6, 1958. Headquarters will be the Queen Elizabeth Hotel.

The tentative program for the Convention follows.

Tuesday, September 2

8:30 a.m.-6:00 p.m. Registration at Convention Headquarters

Registration fee is $20 which includes the Grand Banquet and Ball

10:00 a.m. Full Meeting of the Convention

Meeting of delegates under the chairmanship of the President of the Board

Appointment of Committee on Credentials
Consideration of delegates' credentials

Reading and consideration of Report and General Balance for the period October 1956–May 1958 as presented by the Board in fulfillment of Article 13 (paragraph g) of the Statutes

Election and installation of the Board of Directors of the Convention

Appointment of Honorary Chairman

Appointment of Resolution Committees covering:
(a) Administration
(b) Legislation
(c) Public Relations
(d) Technical Matters
(e) Budget
Special Committees

2:00 p.m. Committee on Teaching of Engineering

2:00 p.m. Committee Meetings:

Administration
Legislation
Public Relations
Technical Matters
Budget

5:30 p.m. Formal Opening of the Fifth Convention

Address by the President of the Board of Directors of UPADI
Brief talk by a North American Delegate
Brief talk by a Central American Delegate
Brief talk by a South American Delegate
Address by the President of the Engineering Institute of Canada

8:30 p.m. Reception given by the Engineering Institute of Canada

Wednesday, September 3

9:00 a.m. Meeting of Technical Committees

2:00 p.m. Meeting of Technical Committees

6:00 p.m. Meeting of UPADI Fund Inc. Board of Directors

8:00 p.m. Meeting of UPADI Board of Directors (Dinner for both Boards)

Thursday, September 4

10:00 a.m. Conference on Engineering Education

2:00 p.m. Conference on Engineering Education

Friday, September 5

9:00 a.m. Meeting of Technical Committees

2:00 p.m. Meeting of the Co-ordination Committee

6:30 p.m. Reception

7:30 p.m. Grand Banquet and Ball

Saturday, September 6

10:00 a.m. Convention Business

Voting on Resolution Projects and Recommendations presented by the Co-ordination Committee

Reading of the Conclusions of the Conference on the Teaching of Engineering

Election of three Board Members to substitute for those leaving as of December 31st. (Outgoing Members: Argentina, Brazil, and the United States)

Determination of location of Sixth Convention to be held in 1960

3:00 p.m. Formal Closing of the Convention

Speech by the President of the Engineering Institute of Canada

Resume of the principal resolutions and recommendations of the Convention made by one of the Secretaries

Brief talks by the representatives of the delegates concerning the proceedings

Speech by the President of the Convention

Those planning to attend the UPADI Convention should send check for registration fee of $20 Canadian, per person, to Engineers Joint Council, 29 W. 39th St., New York 18, N. Y., to arrive not later than August 1, 1958.

News of the AIEE Insulated Conductors Committee

The life of modern paper-insulated lead-covered cables is substantially a function of the reliability of the sheath and its protective coverings. Much necessary work has been and is continuing to be done in the laboratories to improve sheath life. However, only limited field data are available largely because of the complexity of the problem of gathering and analyzing it. Even on so long an established practice as cable arc-proofing, there exist real differences of opinion among engineers on the need and effectiveness of the various coverings.

The Sheaths and Coverings Subcommittee of the Insulated Conductors Committee is collecting test and field data on arc-proofing and has brought to light the investigations of a few companies which have led them essentially to discontinue the practice. Of broader import is a program to relate laboratory and field data on life to fatigue cracking of lead and lead alloy sheaths. To date, the problem has been one of establishing a workable program reasonably subject to analysis. Looking toward improved materials, investigations are being made of sheaths constructed from aluminum, steel, and copper. Looking further ahead, studies are being made of the possibility of using plastic pipe, particularly for pipe cable to reduce a-c losses and to eliminate the now necessary corrosion protection.

Engineering Societies Secretaries Meet in Cleveland

The Council of Engineering Society Secretaries held their annual meeting in the Hotel Cleveland, May 12-14, 1958. The objectives of the meeting were to discuss and mutually exchange information on various society operational problems such as hotel services, finances, public relations, intersociety communications, and publications.

Officials elected for 1958-59 were as follows: President, A. R. Putnam, assistant executive secretary, American Society of Tool Engineers; Vice-President, W. H. Evans, executive secretary, Engineers Society of Milwaukee; Secretary, O. B. Schier II, secretary, American Society of Mechanical Engeneers; and Treasurer, W. P. Youngclaus, executive secretary, American Society for Quality Control.

Luncheons were held during each of the three days. The speaker at the first luncheon was Louis Seltzer, editor of the *Cleveland Press*, on the subject of "What's Ahead." At the second luncheon, C. E. Davies, executive director, United Engineering Center Project, spoke on the plans and progress for the new United Engineering Center in New York City. The talk at the third luncheon was given by R. O. Eastman, head of the Eastman Research Organization, on the subject of elements which forced a readership of society publications.

In a first panel discussion on publications, the value of an audited circulation was considered and John Sasso, vice-president of G. M. Basford Company, told how agencies evaluate media. The second panel discussion was concerned with the facts that make engineering society publications valuable as media.

AIEE FELLOWS ELECTED

Board of Directors Meeting, April 30, 1958

Frederick Thomas Bear (AM '23, M '31), vice-president in charge of engineering, Delaware Power & Light Company, Wilmington, Del., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to increased capability of electric power systems." Mr. Bear was born in Shady Grove, Pa., September 9, 1900. He received the B.S. degree from Pennsylvania State College in 1922. After graduation, he began his career as a design engineer with the Philadelphia Suburban Gas and Electric Co., Phoenixville and Jenkintown, Pa. He then spent a short time with the Philadelphia-Suburban Counties Gas and Electric Co., Norristown; and the United Gas Improvement Co., Philadelphia. In 1929, he joined Delaware Power & Light Company as assistant electrical engineer. He was promoted to electrical engineer in 1942. Since then he has held the titles of chief engineer, manager of engineering, and assistant vice-president of engineering. He became vice-president of engineering in 1957. Since 1947, Mr. Bear has been a member of the Electrical Equipment Committee of the Edison Electric Institute. He is a member of Tau Beta Pi, Eta Kappa

F. T. Bear

Portrait by Nakash
Milton Eaton

Courtesy Walter T. Cocker
F. X. Lamb

Nu, the American Society of Mechanical Engineers, and is a registered professional engineer in the State of Delaware. Mr. Bear served as chairman of the Wilmington Subsection (now the Delaware Bay Section) of the Institute, 1947-48. He has been a member of the AIEE Power Generation Committee (1952-53).

Milton Eaton (AM '44, M '47), consulting electrical engineer, Shawinigan Falls, Que., Canada, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design and automatic control of electric steam generators." Mr. Eaton was born in Whitewater, Man., Canada, August 24, 1892. He graduated from McGill University in 1921 with the B.S. degree in E.E. For many years he was employed as chief electrical engineer with Shawinigan Chemicals Limited. While employed with Shawinigan Chemicals, he served as a consultant on electric steam generators for the Shawinigan Water & Power Company. In this capacity, he was responsible for the development of automatic controls for the Kaelin Electric Steam Generator, and later for the invention of a completely automatic electrode boiler with a new principle of operation. Mr. Eaton was the chairman of the St. Maurice Valley Section of the AIEE when it had its beginning as a Subsection of the Montreal Section. He is a member of the Engineering Institute of Canada (EIC) with which he has served in various executive capacities including that of councilor. Mr. Eaton is the author of a number of technical papers including "Control of Electric Boilers," which appeared in *Electrical Engineering*, October 1947, and "Improvements in Electrode Boilers," published in the Engineering Journal of the EIC, June 1953, for which he was awarded the Ross Medal.

Francis Xavier Lamb (AM '36, M '44), vice-president, engineering, Weston Instruments, Division of Daystrom, Inc., Newark, N. J., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to electrical measurements by invention and by design, especially for exacting and rugged military service." Mr. Lamb was born August 5, 1905, in Newark, N. J. He graduated from the Newark Technical School in 1927 and from the Newark College of Engineering with a B.S. degree in 1930. He was employed by the Weston Electrical Instrument Corporation in 1921 and earned his college degree while working on a co-operative student plan. In 1930, he was made chief of the Commercial Engineering Division. From 1937 through 1939, he was resident engineer for Weston, assigned to the Nippon Electric Company, Tokyo, Japan. From 1940 to 1942, he was a senior development engineer. From 1943 through 1944, he was liaison engineer assigned to Sangamo Electric Company, Springfield, Ill. In 1944, he was promoted to assistant chief engineer of Weston and in 1952 he became chief engineer. He is presently vice-president and chief engineer of Weston Instruments, Division of Daystrom, Inc. Mr. Lamb is an honorary member of Eta Kappa Nu and a licensed professional engineer in New Jersey. He holds numerous patents on design and improvements of electrical indicating instruments. Mr. Lamb served on the AIEE Instruments and Measurements Committee (1951-52).

Robert Olwine Loomis (AM '39, M '47), chief planning engineer, Georgia Power Company, Atlanta, Ga., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the planning and development of a large electric power system." Mr. Loomis was born in Columbus, Ohio, June 21, 1903. He graduated from Ohio State University in 1924 with the B.E.E. degree. During the years 1924 to 1929, he was on the Junior Engineers Training Course of the Alabama Power Company and held various positions with the Alabama Power Company and Gulf Electric Company. In 1929, he joined the Georgia Power Company as distribution engineer. He became special engineer in 1945, planning engineer in 1954, and was named to his present position as chief planning engineer in 1956. Since 1945, most of his time has been spent on transmission problems associated with the growth of the company from a peak load in 1945 of approximately 600 mw to a peak load in 1957 of approximately 2,000 mw. Mr. Loomis has been active in the Georgia Section of the AIEE, serving as secretary-treasurer, 1944-47; vice-chairman, 1947-48; and chairman, 1948-49. He is a member of the Georgia Engineering Society, Eta Kappa Nu, Tau Beta Pi, and is a registered professional engineer in the State of Georgia. Mr. Loomis is a member of the American Standards Association C57 Subcommittee on Power and Distribution Transformer Standards, 1947-58. He is serving on the AIEE Transformers Committee (1957-58) and Research Committee (1957-58).

William B. Loper (M '42), chief engineer, California Electric Power Company, Riverside, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of a rapidly expanding electric power system." Mr. Loper was born in Montrose, Colo., November 2, 1896. He received the B.S. degree from the University of Colorado in 1918. After graduation he served in the U.S. Navy and became an Ensign for engineering duties. From 1919 to 1922, he was with the Chickasaw Shipbuilding Company. In 1922, he joined the Southern Sierras Power Company (predecessor to the California Electric Power Company) as local agent in Barstow. During the years 1924 to 1942, he was employed with the

Kislak Photographers
R. O. Loomis

W. B. Loper

company as local agent, Brawley; electrical engineer, Distribution Section, Riverside; assistant distribution engineer; and assistant to the chief engineer. In 1942, he entered Naval service as Lt. Commander. He was promoted to Commander in 1945 and received a citation from the Chief of the Bureau of Ships for outstanding performance in electrical engineering as an electrical inspection officer. In 1946, he returned to the California Electric Power Company as assistant chief engineer and in 1949 became chief engineer. He became a Captain in the U.S. Navy in 1955 and has been active in reserve work. Mr. Loper was active in the formation of the Riverside-San Bernardino Subsection of the AIEE and was elected its first chairman in 1954. He served on the AIEE System Engineering Committee (1952-56).

E. R. Moore

R. F. Stevens

Edward Royal Moore (M '40), manager of engineering, The Detroit Edison Company, Detroit, Mich., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions in the plannning and development of a large electric power system." Mr. Moore was born in Williamsport, Pa., November 28, 1898. He received the B.S. degree in E.E. from Pennsylvania State College in 1920. From 1920 to 1926, he was employed by the General Electric Company in the Test Course at Schenectady, and later as a sales engineer at Chicago and Detroit. In 1926, he joined The Detroit Edison Company as an engineer in the Electrical Engineering Division. He was appointed budget engineer for proposed expansion projects on the electrical system in 1941 and was made assistant to the chief engineer of the system in 1945. In 1949, he was appointed assistant chief engineer of the engineering department and in 1952 he assumed the duties of chief engineer. In 1954, he became assistant manager of engineering and in 1955 was named manager of engineering. Mr. Moore has been a member of the AEIC (Association of Edison Illuminating Companies) Committee on Power Distribution since 1951, serving as chairman, 1953-56. He was one of the electric light and power group representatives on the ASA Electrical Standards Board from 1952 to 1955, and has been an electric light and power group representative on the ASA Standards Council since 1955. He is a member of the American Power Conference Industry Committee—Electric System and Research and Development Divisions. Mr. Moore is past president of the National Executive Council of Tau Beta Pi, a member of Eta Kappa Nu, The Engineering Society of Detroit, and of Conference Internationale des Grands Reseaux Electriques. He is a registered professional engineer in the State of Michigan.

Richard Francis Stevens (AM '36, M '43), chief of design, Bonneville Power Administration, Portland, Oreg., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of major high voltage power systems in the Pacific Northwest." Mr. Stevens was born in Columbus, Ohio, June 5, 1902. He received the B.S. degree in E.E. from the University of Washington in 1924 and the professional E.E. degree from the same university in 1952. He also completed the electronics and radar courses for Naval officers at Princeton University and Massachusetts Institute of Technology in 1943 and 1944. Mr. Stevens began his engineering career in 1924 on the Westinghouse Graduate Student Course. This was followed by a year as electrical tester with the Puget Sound Power and Light Company. From 1926 to 1938, he was with the Seattle Municipal Light and Power System. In 1938, he joined the then recently organized Bonneville Power Administration (BPA) where he has held the positions of chief of substation design, assistant chief of design, and chief of design. During World War II, he left the BPA for three years of Naval service during which he received a citation. Since the war, he has been active in the Naval Research Reserve and now holds the rank of Commander, USNR. Mr. Stevens is the author of a number of technical papers. He is a member of Tau Beta Pi, Sigma Xi, and Conference Internationale des Grands Reseaux Electriques. His AIEE activities have included a year as secretary-treasurer of the Seattle Section. He is a member of the AIEE Substations Committee (1949-58) and served as chairman of the Transmission Substation Subcommittee. He has also been a member of seven AIEE technical working groups.

AIEE PERSONALITIES

R. J. Bibbero (M '53), acting head of the automation department, Bulova Research and Development Laboratories, Inc., Woodside, N. Y., has been appointed chief engineer, applied science department. In his new position, Mr. Bibbero directs the Laboratories' work in the areas of weapons systems and industrial systems analysis, systems management, and staff consulting activities in applied science and mathematics.

H. H. Brauer (AM '38, M '43), chief electronics engineer, Bell & Howell Company, has joined Fansteel Metallurgical Corporation as staff assistant to the general manager of Fansteel's Rectifier-Capacitor Division. His principal activities at Fansteel are systems and procedures in accounting, production controls, scheduling and marketing, particularly the mechanization of these procedures with punched cards. Mr. Brauer has served on the AIEE Instruments and Measurements Committee (1944-49).

G. W. Brown (AM '52), vice-president in charge of engineering and research, Wagner Electric Corporation, St. Louis, Mo., has been elected executive vice-president. **P. C. Ford** (AM '38, M '44), executive engineer, directing the company's automotive and electrical engineering and research facilities, has been elected vice-president in charge of engineering and research.

L. R. Gamble (AM '23, F '39), has retired as chief engineer of The Washington Water Power Company, Spokane, Wash. **C. E. Cannon** (AM '56), chief electrical engineer of the company, has been appointed chief engineer. Mr. Gamble has been active in the AIEE as chairman of the Spokane Section, Institute vice-president for District No. 9 (1938-40), a director (1941-45), and liaison representative on Standards Committee. He has served on the following AIEE Committees: Standards (1932-50), Production and Application of Light (1938-40), Automatic

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CORRECTION: In connection with the biographical sketch published on the occasion of A. J. Fetzinger's transfer to the grade of Fellow (*Electrical Engineering*, January 1958, p. 95), the following two points are presented to correct unintentional inaccuracies:

1. The Sangamo Company Limited of Canada began manufacturing a combination polyphase watt-hour and thermal watt demand meter in 1931. This precedes the development mentioned in the biography by roughly 15 years.
2. The Sangamo Company Limited of Canada also manufactured a combination polyphase watt-hour and thermal kva demand meter in 1922. Such a meter has also been made in this country by Sangamo Electric Company since 1954. This was a displaced voltage type of meter which was accurate over a limited range of power factor, and taps were provided for various power factor settings. This precedes the Westinghouse development referred to by almost 30 years. The Westinghouse meter developed in 1949 is independent of power factor variation.

Stations (1941-45), Protective Devices (1942-45), and Domestic and Commercial Applications (1944-49). He is a registered professional engineer in the States of Idaho and Washington. Mr. Cannon is also a past chairman of the Spokane Section. He is a registered professional engineer in the State of Washington.

P. E. Cook (AM '20, M '36), consulting engineer and assistant to the general manager of Allis-Chalmers Manufacturing Company Pittsburgh Works, retired recently after more than 25 years with the firm. Mr. Cook is a registered professional engineer in the State of Pennsylvania.

N. J. Dean (M '57), director of data processing consulting for the Ramo-Wooldridge Corporation, has joined Booz, Allen & Hamilton, management consultants, as director of electronic data processing for the nation-wide firm's central region.

E. J. Diebold (AM '51, M '56), chief design engineer, Heavy Duty Power Division, International Rectifier Corporation, El Segundo, Calif., has been named director of the heavy duty product department. He will direct all engineering activities concerned with germanium and silicon rectifiers for heavy duty equipment, such as electrochemical installations. Mr. Diebold is a member of the AIEE Industrial Power Rectifiers Committee (1955-58), and past chairman of the Mechanical Rectifier Subcommittee.

A. B. Du Mont (F '43), chairman of the board of directors of Allen B. Du Mont Laboratories, Inc., Clifton, N. J., was named "Engineer of the Year" by the New Jersey Society of Professional Engineers at their annual convention in Atlantic City, N. J., recently. Dr. Du Mont was honored not only for his achievements that led to television but for his engineering developments that led to vital electronic devices such as radar, loran, and oscilloscopes.

S. H. Ekefalk (M '56), technical director and vice-president of the Swedish State Power Board, has been appointed deputy managing director of Atlas Copco AB of Stockholm, Sweden. He will assume his new duties during the summer. Mr. Ekefalk has been responsible for the Swedish State Power Board's entry into the nuclear power field. Under his direction, a special Power Board department was established to speed development of atomic power stations.

E. C. Easton (M '44), dean of engineering, Rutgers University, New Brunswick, N. J., has been named by the American Society for Engineering Education (ASEE) as vice-president in charge of activities of the ASEE's instructional divisions. **John Gammell** (AM '38, M '45), director of graduate training at the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., was re-elected treasurer of the ASEE for his third one-year term. Dean Easton is a member of the Council of the American Association for the Advancement of Science. Mr. Gammell has served on the following AIEE Committees: Transfers (1947-50), General Industry Applications (1949-50), and Education (1955-58).

N. W. Gaw, Jr. (AM '56), of Kinnelon, N. J., has joined Measurements, a McGraw-Edison Division, Boonton, N. J. He will head the laboratory at Measurements' Succasunna plant. Mr. Gaw will be responsible for engineering on Government research and development contracts and other special projects.

E. W. Greenfield (AM '34, F '51), research supervisor of Kaiser Aluminum & Chemical Corporation's department of metallurgical research, Spokane, Wash., has resigned to become director of the Division of Industrial Research, Institute of Technology, Washington State College, Pullman, Wash. Mr. Greenfield has served on the AIEE Electronics Committee (1948-49) and Chemical Industry Committee (1955-58).

J. W. Hostetter (AM '41, M '47), professor of electrical engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., has been named assistant dean. In his new post, Dean Hostetter will be in charge of Polytechnic's evening sessions in engineering and science.

D. S. Kellogg (AM '39, M '55), chief engineer, General Precision Laboratory, Pleasantville, N. Y., has joined Nuclear Development Corporation of America, White Plains, N. Y., as a consulting engineer. Mr. Kellogg is a senior member of the Institute of Radio Engineers and a member of Tau Beta Pi and Sigma Xi.

A. K. Kuhnel (AM '44, M '53), assistant manager of The Austin Company's Special Devices Division, has been named manager of the division with headquarters at the New York Port Authority Building. Mr. Kuhnel is a member of the Society of American Military Engineers and the National Society of Professional Engineers.

C. I. MacGuffie (AM '27, M '43), manager of marketing, welding department, General Electric Company, has been elected first vice-president of the American Welding Society. Mr. MacGuffie is also a member of the American Ordnance Association and past chairman of the Welding Section of the National Electrical Manufacturers' Association. Mr. MacGuffie has served on the AIEE Electric Welding Committee (1940-41, 1943-47).

W. G. Meese (AM '47, M '57), assistant director of the Detroit Edison Company's engineering laboratory and research department, has been appointed director. Mr. Meese is a member of the Engineering Society of Detroit and the Research Projects Committee of the Edison Electric Institute. Mr. Meese has served on the AIEE Domestic and Commercial Applications Committee (1949-52) and Research Committee (1954-58).

R. E. Neidig (AM '38, F '57), chief engineer, Metropolitan Edison Company, Reading, Pa., has been elected vice-president and chief engineer. He will continue in charge of the company's engineering work. Mr. Neidig is past chairman of both the Communications Committee and the Electrical Equipment Committee of the Pennsylvania Electric Association. He is also a past chairman of the Lehigh Valley Section of the AIEE. Mr. Neidig has been a member of the AIEE Carrier Current Committee (1947-49) and Protective Devices Committee (1951-55).

J. R. Ragazzini (AM '33, M '50), chairman of the electrical engineering department at Columbia University's School of Engineering, has been named dean of New York University's College of Engineering. An authority on electronic computers, control systems, and related devices, Dr. Ragazzini has conducted and directed numerous research projects. A result of one project is the U. S. Air Force's "Ragazzini Computer" or "Ragatrack," a device that automatically guides interceptor planes toward approaching enemy aircraft. Dr. Ragazzini has served on the AIEE Feedback Control Systems Committee (1951-58, chairman 1956-57) and Industry Division (1956-57).

L. C. Schaefer (AM '39), engineering manager, industrial motor department, Westinghouse Electric Corporation, has been appointed vice-president in charge of engineering, Torq Engineered Products, Inc., Bedford, Ohio. Mr. Schaefer is a member of Eta Kappa Nu and Tau Beta Pi. He is a member of the AIEE Rotating Machinery Committee (1957-58).

R. C. Sprague (M '40, F '49), chairman of the board of the Sprague Electric Company, North Adams, Mass., has been named "Man of the Year" by the alumni of the Hotchkiss School. Mr. Sprague was a member of the class of 1918 at the Lakeville, Conn., preparatory school. He is on the Advisory Committee, National Bureau of Standards.

H. L. Hoeppner (AM '18, F '43), has resigned his position as consulting electrical engineer, Pioneer Service & Engineering Co., Chicago, Ill. **T. O. Millard** (AM '29, F '51) application engineer, General Electric Company, has been appointed chief electrical engineer of the company. Mr. Hoeppner served on the AIEE Power Generation Committee (1939-40).

J. L. Devitt (AM '50), manager of the Electrochemical Division, Frank R. Cook Co., Denver, Colo., has been named chief engineer of the aviation-electronics firm. In his new position, Mr. Devitt will be responsible for design, development, quality control, and service engineering of the company's miniature battery program.

OBITUARIES

Frederick Bedell (AM '91, F '26), professor emeritus of physics, Cornell University, died recently. He was 90 years old. Dr. Bedell was born in Brooklyn, N. Y., in 1868. He received the B.A. degree in 1890 from Yale University and the Ph.D. in 1892 from Cornell. He joined the faculty of Cornell in 1892 as instructor in

the department of physics. He became assistant professor of physics in 1895 and professor in 1904. He retired from his position and became professor emeritus in 1937. Dr. Bedell was a member of several technical societies including the American Academy of Arts and Sciences, American Physical Society, Optical Society of America, Eta Kappa Nu, and Sigma Xi. He had been a vice-president of the Institute (1917-18) and had served on the following AIEE Committees: Edison Medal (1917-23); Editing (1916-17); Electrophysics (1914-19, chairman 1917-18); Meetings and Papers (1916-18); Research (1920-22); Sections (1914-16); and Standards (1915-22).

Benjamin B. Bessesen (AM '17, M '27, Member for Life), electrical engineer, North Pacific Division, U. S. Army Corps of Engineers, died recently. Mr. Bessesen was born March 17, 1887, in Portland, Oreg. He attended the University of Washington, from which he received his engineering degree, and Oregon State College. During his career, he had served as an instructor in electrical engineering at Oregon State College, and as an engineer with the U. S. Bureau of Reclamation and the Tennessee Valley Authority. During World Wars I and II, he served as an officer with the Army Engineers. Since 1946, he had been employed by the Corps of Engineers division office at Portland, Oreg. Mr. Bessesen was a member of the American Society for Engineering Education, the Society of American Military Engineers, and is listed in "Who's Who in Engineering."

John James Chapman (AM '40, M '55), research contract director, Dielectrics Laboratory, The Johns Hopkins University, Baltimore Md., died recently. Dr. Chapman was born February 12, 1913, in Baltimore. He received the degrees of B.E. in 1935 and D.Eng. in 1940, both from Johns Hopkins University. From 1940 to 1945, Dr. Chapman was a development engineering assistant in the Electrical Research Section of the General Electric Company's Pittsfield Works Laboratory. In 1945, he became assistant research contract director for Government sponsored research on dielectrics at Johns Hopkins University and in 1952 he became director. Dr. Chapman was a member of the Electrochemical Society and the American Society for Testing Materials. He was a fellow of the American Association for the Advancement of Science. He had served on the AIEE Dielectrics Committee (1957-58).

Noel Bertram Hinson (AM '19, F '35), former vice-president and executive engineer for Southern California Edison Company, died recently. Mr. Hinson joined the Edison organization in 1906 and held a number of positions during his 44 years of service. He became chief engineer and chairman of the company's engineering committee in 1934 and was elected vice-president and executive engineer in 1945. At the time of his retirement in 1950, he was chairman of the Pacific Southwest Power Interchange Committee. Mr. Hinson was a member of the American Association for the Advancement of Science and the Electric Club of Los Angeles. He had been active in the Institute, serving on the following AIEE Committees: Power Generation (1935-41); Special Committee on Registration of Engineers (1942-46); Constitution and Bylaws (1949-53, chairman 1949-51); Planning and Co-ordination (1949-50); Safety (1949-53); Members-for-Life Fund (1952-53); and Board of Directors (1949-53).

Ferdynand M. W. Strojny (AM '35), senior design engineer, Sylvania Electric Products, Inc., Danvers, Mass., died recently. Mr. Strojny was born in Taunton, Mass., in 1907. After graduating from Worcester Polytechnic Institute in 1930, he joined the Consolidated Edison Company of New York. He joined Sylvania in 1943 and worked in both the Process Engineering and Design Sections. Mr. Strojny was a member of the Management Club of Sylvania, a registered professional engineer, and chairman-elect of the Lynn Section of the AIEE.

John Petermann Voight (AM '45), manufacturers representative, died recently. Mr. Voight was born July 6, 1898, in Summerville, S. C. Following graduation from Clemson College in 1920 with a B.S. degree in E.E. and M.E., he was employed by the General Electric Company for four years in the electrical test and engineering drafting departments. From 1924 to 1926, he was associated with Stone & Webster as design engineer. Since 1926, he had been employed as sales representative for Railway & Industrial Engineering Company in the Southeast and other equipment manufacturers. He was a veteran of World War I.

Lewis Brown Blalock (AM '45), assistant vice-president, Texas Power & Light Company, Dallas, Texas, died recently. In 1925, Mr. Blalock was employed by Texas Power & Light Company as a power sales engineer. He later became supervisor of industrial sales and in 1948 he organized the company's Industrial Development Section of the sales department. He was made assistant vice-president in May 1955. Mr. Blalock was a registered professional engineer and was a member of the Texas Society of Professional Engineers and the Petroleum Electric Power Association. Mr. Blalock served on the AIEE General Industry Applications Committee (1950-54).

William N. Chaffee (AM '10, Member for Life), assistant manager, Board of Water Supply, City and County of Honolulu, T. H., died recently. Mr. Chaffee was born January 31, 1879, in Detroit, Mich. He graduated from the University of Michigan in 1902, after which he joined Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation).

Charles Nelson Metcalf (M '46), senior engineer, Consolidated Edison Company of New York, New York, N. Y., died recently. Mr. Metcalf was born August 29, 1904, in Buffalo, N. Y. He received the E.E. degree from Rensselaer Polytechnic Institute in 1926. After graduation, he was employed in the test department of the New York Edison Company (now Consolidated Edison Company of New York). During the years 1929 to 1942, he worked in the transmission and distribution department, distribution engineering department, and electrical engineering department. In 1942, he became a Lieutenant in the Civil Engineering Corps, U. S. Navy. In 1944-45, he served as head of the Electrical Section, Advanced Base Department, Bureau of Yards and Docks, Washington, D. C. He was also assigned to the Defense Electric Power Administration in Washington as power analyst in the Power Supply Division. He held the rank of Commander, Civil Engineering Corps, USNR. Mr. Metcalf was a registered professional engineer in the State of New York. He had served on the AIEE System Engineering Committee (1953-58) and had been vice-chairman of the Committee.

Lucius Lamar Patterson (M '24, F '51), dean emeritus, School of Engineering, Mississippi State College, died recently. Dean Patterson was born February 8, 1879, in Enid, Miss. After graduating from Mississippi College in 1898, he received an M.A. degree in mathematics from his alma mater, and in 1906 a master's degree in engineering from Cornell. He received the honorary degree of doctor of laws from Mississippi College in 1948. He joined the faculty of Mississippi College as assistant professor of electrical engineering in 1909 and was appointed head of the department in 1914. In 1930, he became dean of the School of Engineering, continuing in this capacity until his retirement in 1949. Dean Patterson was a member of the National Council of State Boards of Engineering Examiners. He once served as president of the Southeastern Section of the American Society for Engineering Education. He was a registered professional engineer in Mississippi, a charter member and former president of the Mississippi Society of Professional Engineers, a member of the National Society of Professional Engineers, and since 1932 he had served on the Mississippi State Board of Registration for Professional Engineers. He was a charter member of the Mississippi State College chapter of Tau Beta Pi.

Timothy Henry Murphy (AM '49, M '53), of the Westinghouse Electric Corporation, Pittsburgh, Pa., died recently. Mr. Murphy was born May 18, 1903 in Lynchburg, Va. He received the E.E. degree from the University of Virginia in 1923 after which he joined the Westinghouse Student Course. He served as application engineer, Railway Division, general engineering department, from 1924 to 1932, and as project engineer, diesel engineering department, from 1932 to 1936. During the years 1936 to 1948, he was employed by the American Locomotive Company. He then worked for G. A. Holder Company, returning to Westinghouse in 1949 as transportation service supervisor. Mr. Murphy was a member of the American Society of Mechanical Engineers. He had served on the AIEE Land Transportation Committee (1942-48, 1955-57).

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OF CURRENT INTEREST

Fluorescent Strip System Spreads Carpet of Light for Landings

INSTALLATION of a new, 1,400-foot fluorescent lighting system that spreads a carpet of light across the runway at Washington (D.C.) National Airport for low-visibility landings was announced recently by airport officials and Sylvania Electric Products Inc.

Floodlighting

The runway floodlighting, developed jointly by Sylvania and the Civil Aeronautics Administration (CAA), consists of 272 VHO (very high output) fluorescent lamps installed in lightweight, 30-inch-high reflector fixtures extending along both sides of the runway. The continuous, 1,400-foot lines of light are broken only by an intersecting taxiway.

The VHO strip lights are said to represent a major advance toward all-weather operations by illuminating the "black hole" that exists between incandescent beacon-type lights now commonly lining runways. This type of illumination supplies landing planes with the vital height guidance that is absolutely essential with the accelerated landing speeds of modern aircraft.

The new lighting system was installed on Washington's instrument runway #36 for in-service tests which are being conducted by the CAA.

The installation represents the "culmination of some three years of research and development work in the engineering laboratories of Sylvania Lighting Products in Salem and Ipswich, Mass., together with continuing equipment tests by the CAA," it was asserted at the official lighting ceremonies at which interested personnel from the airport and company were present.

Early Runway Identification

The company, a pioneer in the airport lighting field, also has worked with the CAA in development of the now-standard EFAS (electronic flash approach system), which provides early runway identification for incoming planes (*Electrical Engineering*, March 1956, p. 302).

Large reflectors within the new aluminum floodlight fixtures, mounted 13 feet beyond the outside edges of the runway, spread the light horizontally across the runway surface in a manner that eliminates the possibility of upward glare. The 1,400-foot strips of light begin 200 feet from the runway threshold.

Since the 200-watt lamp in each 8-foot fixture has a light output of 13,250 lumens, or more than 2½ times that of an ordinary fluorescent lamp, the complete installation produces about 3.25 million lumens of light—the equivalent of more than 7,000 household lamps of 40-watt strength.

Brilliance and Contrasts

Brilliance of the horizontal lighting is heightened by reflections from a pattern of white paint markings on the runway surface, which contrasts sharply with the black runway. The lighting also brings out vividly texture irregularities in the runway surface that provide the incoming pilot with an additional depth perception gauge—as well as guidance on speed and angle of approach.

▲ CARPET OF LIGHT permits an airliner to touch down on Washington National Airport's instrument runway #36—its path illuminated by a new, 1,400-foot fluorescent lighting system for low-visibility landings developed jointly by Sylvania Electric Products Inc. and the CAA. The illuminated outline of the Washington monument is visible at left along the city's skyline. The bright light on right horizon is on the Capitol dome.

Mr. Gates said the new VHO strip lighting system was installed at Washington National Airport "to determine how illumination of the runway surface and markings under very low visibility conditions gives landing pilots better height sensitivity and directional and roll guidance in the final stages of their landing approach and in the touch-down area."

The most significant test at Andrews A.F.B. came during early-morning meteorological conditions of "zero-zero" weather, when a CAA *DC-3* and an American Airlines *Convair* reported "little glare, good runway texture and good height guidance" from the VHO runway strip lights.

Advantages

It was stated that, in addition to illumination of the "black hole," the major advantages of the strip lights are a minimum of upward glare and a design that eliminates the possibility of damage to the aircraft in the event it goes off the side of the runway. The present beacon-type

runway lights tend to illuminate surrounding fog or haze—producing a broad glow that can obscure a landing pilot's vision. Because the runway illumination provided by the strip lights extends upward only a maximum two to three feet, the possibility of such intense upward glare is eliminated.

"Propeller and wing clearance are assured by the units' 30-inch height," Sylvania officials said. "Even if struck by an airplane, the fixtures would break off easily because of a 'frangible' coupling which also cuts the electrical power circuit upon impact."

The VHO runway strip lights, manufactured at Sylvania's Ipswich, Mass., plant, are being tested as part of the total system of visual and electronic aids to approach and landing under restricted visibility conditions.

EIGHT-FOOT FLUORESCENT LAMP developed for the VHO (very high output) runway striplight system which spreads a carpet of light across the runway for low visibility landings is explained to L. W. Burton (center), airport director, and R. F. Gates (right), flight operations specialist, CAA, by O. R. Lail, special aviation representative of Sylvania.

Polaris Prototype Tested by Hurling Huge Dummy

THE U.S. NAVY today revealed hitherto classified details of the launching system for the *Polaris* intermediate-range ballistic missile, a prototype of which is hurling huge dummy missiles skyward many times each week at the San Francisco Naval Shipyard.

Terming the first land launchings "highly successful," Rear Adm. W. F. Raborn, director of the Special Projects office, Bureau of Ordnance, said the massive device is a development version of unique launch equipment designed to blast the *Polaris* off on the initial part of its journey through space and back.

The solid-fueled *Polaris*, expected to have operational capability in 1960, is being designed for launching from submerged submarines. This factor makes its launch system much more sophisticated than launch techniques for land-based long-range missiles.

The test device is a giant tube supported to its midpoint by A-shaped tubular steel brackets. With scaffolding around its top to aid technicians working on the tests, it looks like a crazily tilted lighthouse.

But this "lighthouse" throws a multiton dummy missile many feet in the air. The dummy carries instrumentation to show how well it stands up under the sudden acceleration of launching.

The test program leading to final production of a ship-borne launcher is being conducted at the Naval Shipyard as a joint effort of Westinghouse Electric Corporation, in charge of launcher development, and Lockheed Missile Systems division, missile system manager for *Polaris*.

"Various portions of the over-all *Polaris* weapon system are now moving along in parallel development which will permit the earliest possible fleet assignment of the weapon," Adm. Raborn said.

The admiral stressed that no live missiles are being fired in the San Francisco Bay area.

"The dummy missiles fired from Hunter's Point are made of steel and concrete," he said. "They fall harmlessly into the bay only a few yards from the launcher; then they are recovered from the water to be studied and used again."

In order to get readings from the instruments within the dummy missile, Lockheed engineers devised an unusual "extension cord" system. They attach a tough electric cable to the projectile's nose and run it out the mouth of the launcher to a nearby instrument hut. Through this cable reports of strain gauges, pressure gauges, and accelerometers are communicated during the firing to equipment inside the hut.

When the dummy missile has risen from the launcher, the cable separates and falls to earth, its mission completed until the next launch.

After the dummy completes its flight and plunges to the bottom of the bay, it is recovered in a unique "missile overboard" operation, reminiscent of the prenuclear Navy.

A small life preserver is attached lightly to its nose before the firing. It is fastened to a long, strong rope which uncoils as the missile flies through the air.

In recovery, the crew of a small boat pulls in the floating life preserver with a boat hook, then attaches the rope leading down to the missile to a giant crane. The dripping model is then hoisted clear of the water and returned to the pier where it is readied for another blast-off.

The trial firings were labeled "Operation Peashooter" and were made from the Westinghouse experimental test installation at the San Francisco Naval Shipyard. Some of the mock-up missiles are constructed of redwood, which floats in water, simplifying their recovery. Underwater tests are under way at other experimental sites.

The *Polaris* missile, with its range of 1,500 miles, will have flexibility and mobility unique to naval operations and will extend the nation's defense perimeter to greater distances. The challenges of launching the *Polaris* under various weather conditions and vessel motions, on the surface and under the water, are being met by a special team of engineers and scientists. Under water, the missile must be able to "take off and fly" on short notice.

The launcher development group has been built around a nucleus of engineers who developed and directed the production of the Navy's 3-inch automatic rapid fire antiaircraft guns now in successful op-

Official Photograph, U.S. Navy

UP OUT OF THE MOUTH of the launcher goes a heavy concrete-and-steel dummy missile used to simulate the U.S. Navy's *Polaris* fleet ballistic missile in development tests of the launching system. A careful inspection of the photograph will show small life preserver attached to the "Missile's" nose to aid in its recovery from the bottom of the bay, and an electric cable to relay information about the launch to equipment in an instrumentation hut.

Official Photograph, U.S. Navy

HEAVY CLOUD OF SMOKE trails from mouth of prototype launcher for the U.S. Navy's *Polaris* fleet ballistic missile, undergoing testing at San Francisco Naval Shipyard, Hunter's Point, Calif. At upper right, huge dummy missile made of concrete and steel can be seen falling toward the bay, after successful launch. The dummy is then retrieved from the bay for study and re-use.

eration on naval vessels. Supplementing these engineers is an advanced development group of scientists transferred from other Westinghouse operations, including ordnance personnel from the Transformer Division at Sharon, Pa., and representatives of the aviation gas turbine division at Kansas City, Mo.

Electronic Highway of Tomorrow in Operation

A SEGMENT of the "electronic highway of tomorrow" went into operation recently at the David Sarnoff Research Center of the Radio Corporation of America at Princeton, N.J.

Cars entering the grounds of the research center, headquarters of RCA Laboratories, passed over electronic loops buried in the entrance road. Transistorized detector units connected to the loops counted each of the passing cars, measured the speed of each, and flashed a polite warning saying "Slower Please" to every driver exceeding the posted speed limit.

The new equipment is a transistorized variation of the comprehensive electronic vehicle control system developed earlier by RCA and demonstrated at Lincoln, Neb., in co-operation with the Nebraska Department of Roads (*Electrical Engineering*, February 1958, p. 201-2). At Lincoln, the system showed its ability to guide cars automatically along the highway and to provide electrical signals for the automatic control of braking and steering.

The new RCA Laboratories installation put into operation is designed to demonstrate further immediate applications of the system in specific traffic control jobs. It went to work this morning under the eye of Dr. V. K. Zworykin, honorary vice-president of RCA, who directed development of the entire vehicle control system by an RCA Laboratories research team including L. E. Flory, W. S. Pike, and G. W Gray.

Performs Four Functions

The distinction of receiving the first speed warning fell to Mr. Flory, who purposely drove past the 20-mph speed limit sign at the research center entrance at a smart 30-mph clip. As the car passed over the two wire loops buried in the pavement, four things happened simultaneously:

1. The transistorized detector units connected with the buried loops detected the passage of the car and measured its speed.
2. Since the speed was greater than the specified limit, the circuits automatically illuminated the warning sign at the roadside some 20 yards ahead of the car.
3. A simple counter connected to the detector units recorded the passage of the car.
4. A second counter automatically recorded the passage of a car in excess of the speed limit.

"The idea of such an installation on the highway would be to study driver habits and to determine whether or not a posted speed limit is realistic," said Dr. Zworykin. "By installing such a system at the entrance to the David Sarnoff Research Center, we will have an opportunity to study the functioning of the equipment over extended periods and under all conditions of weather."

Ultimately, according to Dr. Zworykin, another loop can be installed farther along the road to determine how many drivers slow down after receiving the warning from the automatic sign, "thereby giving us another indication of driver reactions."

Uses Components of Highway System

Dr. Zworykin emphasized that the newly installed units are components that would be standard in the comprehensive electronic control system designed for the ultimate automatic control of vehicles on the highway. Like the demonstration equipment at the laboratory entrance, the larger system consists basically of wire loops buried in the pavement along a highway, with detector units associated with each loop to pick up the signals generated by passage of cars over the loop. In the complete system, these signals are fed back through antennas under the road to activate automatic controls in following cars, or they are used to operate various roadside warning devices.

"In the complete system," said Dr. Zworykin, "any segment at any point on the highway can be used to perform the counting and speed measurement functions demonstrated in this laboratory installation.

"Various radar and mechanical techniques are now used for this purpose, but these existing devices require special installation wherever they are to be used, and they bear no relation to the complete system in the highway itself. By using elements of the complete RCA system for these specific and limited functions, a variety of installations can be made in the near future with the assurance that they will function also as integral parts of the more extensive highway installations of tomorrow."

Mr. Flory, as a member of the research team responsible for development of the electronic highway control system, gave this brief description of the way in which the newly installed RCA Laboratories equipment operates:

The detector loops in the roadway itself consist of rectangles of wire 6 x 20 feet in outline. In operation, a voltage from a high-frequency power line is applied to each of the loops. A vehicle passing over the loop causes a variation in the current passing through the wire. This variation is immediately detected by a small transistorized detector circuit placed at the side of the road. The detector circuit then produces an output signal which is used to perform the desired action. In the RCA Laboratories installation, the signals from the detector units activate the counters. In addition, the time interval between the variations in the two loops is measured to determine the speed of the vehicle, and the illuminated sign is turned on if the speed exceeds a predetermined limit.

SEGMENT of RCA electronic highway system used at David Sarnoff Research Center, Princeton, N. J., demonstrates use of excessive-speed warning system. Car passing over wire loops in road is counted, its speed measured, and drivers warned by automatically lighted sign to go "Slower Please." Warning to one driver who purposely exceeded the specified limit of 20 mph is seen.

Device Determines Lighting Requirements

An optical system for determining the lighting requirements of any seeing task was introduced recently to lighting engineers, designers, architects, and ophthalmologists, at the first of a series of regional conferences conducted by the Illuminating Engineering Society (IES). The new technique, described at the Dearborn, Mich., symposium, indicates the need for increases in the recommended lighting levels for a broad variety of standardized lighting classifications. It is the result of an 8-year study conducted at the Vision Research Laboratories of the University of Michigan, Ann Arbor, Mich., and supported by the Illuminating Engineering

Research Institute, an independent research body of the IES.

Representative of the range of necessary lighting modifications indicated by the new measuring technique are the following: for desk-level illumination for an accountant, an increase in foot-candles from the presently recommended 50 to a minimum of 150; in school tasks involving writing with soft-lead pencils, an increase from the presently recommended level of 30 foot-candles to 60; for the work area of a draftsman, a fourfold increase from 50 to 200 foot-candles; and in the garment industry, for such tasks as viewing orange chalk markings on light brown tweed, a 266 foot-candle level as against the present recommendation of 40 foot-candles. In many instances, initial tests have indicated that no modifications are necessary.

Work of University Team. The new evaluation system, developed by Dr. H. R. Blackwell, director of the University of Michigan laboratories, and a team of University of Michigan research specialists in optics and psychology, is considered to be the most scientifically accurate and most comprehensive technique for determining the lighting needs of specific tasks thus far devised, according to C. L. Crouch, technical director of the society.

Dr. Blackwell began developing his new system in 1950 with a series of studies to establish how accurately a variety of subjects could determine the presence of circular targets of diverse sizes exposed to view for varying periods. The targets were designed to simulate various degrees of "difficulty" in seeing specific objects under varying conditions. Thousands of readings were recorded and catalogued. These data became the cornerstone of the system, which is based on the scientific fact that an identical amount of light is required to perform any visual task of total equal difficulty.

Dr. Blackwell explained that "if the lighting engineer knows the amount of light required to perform a given visual task, he can accurately specify the amount of light required by another task equally difficult to see." To relate his accumulated basic data to any given seeing task, Dr. Blackwell developed a complex optical instrument called the Visual Task Evaluator (VTE). With this device, he can view a seeing task for unknown lighting requirements at threshold, or just bare visibility, match it to a test object of known lighting requirements, and quickly determine the lighting requirements from the collected statistical data. The indicated lighting requirement thereafter needs only simple mathematical adjustment to compensate for the differences between the standard data, collected under optimum laboratory conditions, and actual conditions in the field.

Eye "Assimilates" Facts by Bits. While conducting the study, Dr. Blackwell recognized that the average eye sees or "assimilates" visual information by bits, and that the level of illumination determines the number of assimilations the eye can make in a one-second interval. He indicated that the average eye "is easily capable of making 10 such assimilations a second if the light level is sufficiently high." The number of assimilations per second determines the amount of information the eye has absorbed, "and the more information the eye has absorbed, the higher the rate of performance is likely to be," he observed.

In reporting on the application of the Blackwell technique of a new appraisal of IES recommended lighting levels, Mr. Crouch indicated that the Society's technical committees had adopted five assimilations per second (aps) as a reasonable average level of desired performance. The technical committees, he pointed out, are in the midst of compiling new recommended practices for publication in a revised edition of the IES Lighting Handbook due to be released in January 1959.

BR 2 Nuclear Reactor Is Constructed in Belgium

Recently, it was reported that the Centre d'Etude de l'Energie Nucléaire has added another nuclear reactor to its present installation at Mol. The new reactor is a BR 2 (material testing reactor).

The present and future needs of both institute and industry will be facilitated by the new BR 2 installation at Mol.

Now that the BR 1 can be utilized exclusively for fundamental research in nuclear physics, the BR 2 is slated to be used in technological research on the effects of radiation on materials. The reason for using the BR 2 in the latter capacity is the fact that the neutron flux of the new reactor is more than 100 times greater than that attained in the BR 1 reactor.

Undoubtedly, there are other similar reactors throughout the world, but the BR 2 is unique in that its extreme flexibility permits the testing of an infinite variety of materials for internal and external irradiations. In order to reach this goal, it was necessary to design the tank holding the core. Unintentionally, this turned out to be in the shape of a diabolo (hour-glass shaped piece used in a game of the same name). Such a shape permits the greatest concentration of the fissionable material (enriched uranium) to be placed in the center of the tank and ease in removal of part or all core elements.

To improve the design of the core housing, with its high neutron flux of the external irradiations, aluminum was chosen to be used in the construction of the tank. Aluminum is a non-neutron absorbing material. However, the two large lids which close the diabolo are made of stainless steel.

To say that no problems were posed by the placement of the unit, which is more than 20 feet in height, would be senseless. One of the problems encountered was in trying to solder together the two parts of the aluminum diabolo which, in spots, had a thickness of more than 2½ inches, inasmuch as the pressure within the diabolo is set at 15 atmospheres in order for the BR 2 to function.

The reactor was built by Ateliers de Constructions Electriques de Charleroi, Division Nucléaire des ACEC. The reactor tank was manufactured by Les Ateliers de Construction de la Meuse. The refrigeration pumps and control equipment were made by Manufacture Belge de Lampes et de Material Electronique.

Future Meetings of Other Societies

Yale University, joint University of California, course on introduction to computer methods for highway and traffic engineers, July 7-19, Yale University, New Haven, Conn. Director, Bureau of Highway Traffic, Strathcona Hall, Yale University, New Haven, Conn.

IAS, National Summer Meeting, July 8-11, Ambassador Hotel, Los Angeles, Calif. IAS, 2 E 64 St, New York 21, N. Y.

National Safety Council, Farm Safety Week, July 20-26. Farm Division, National Safety Council, 425 N Michigan Ave, Chicago 11, Ill.

Denver Research Institute, 5th Annual Symposium on Computers and Data Processing, July 24-25, Albany Hotel, Denver, Colo. C. A. Hedberg, Electronics Division, Denver Research Institute, University of Denver, Denver 10, Colo.

Illuminating Engineering Society, National Technical Conference, Aug 17-22, Royal York Hotel, Toronto, Ont, Canada.

American Astronautical Society, Annual Western Regional Meeting, Aug 18-19, Dinkelspiel Auditorium, Stanford University, Palo Alto, Calif. M. A. Broner, 3421 Greer Rd, Palo Alto, Calif.

ASME, joint AIChE, Heat Transfer Conference, Aug 18-21, Northwestern University, Evanston, Ill. L. S. Dennegar, ASME, 29 W 39 St, New York 18, N. Y.

The Institute of Radio Engineers

Western Electronic Show and Convention (WESCON), joint WCEMA, Aug 19-22, Pan Pacific Auditorium, Los Angeles, Calif. R. C. Hansen, Hughes Aircraft Co, Culver City, Calif.

4th National Aeronautical-Communications Symposium, Communications Systems, Oct 20-21, Hotel Utica, Utica, N. Y. (classified symposium, auspices Directorate of Communications, Rome Air Development Center, Oct 22, Griffis Air Force Base, Rome, N. Y. Clearance required) R. C. Benoit, 138 Riverview Pky, Rome, N. Y.

EIA, Conference on Reliable Electrical Connections, Dec 3-5, Dallas, Texas. Deadline for papers: Aug 15. R. G. Roesch, 1068 S Clinton St, Syracuse 4, N. Y.

Foreign

International Electrotechnical Commission (IEC), Annual meeting, July 1-16, Stockholm, Sweden.

2nd International Conference for Analog Computations, Sept 1-7, Strasbourg, France.

2nd International Conference on Peaceful Uses of Atomic Energy, Sept 1-15, Geneva, Switzerland. U.N.O.

2nd International Congress on Cybernetics, Sept 3-10, Namur, Belgium. Secretariat, International Association for Cybernetics, 13, rue Basse-Marcelle, Namur, Belgium.

ICAS, 1st International Congress of the Aeronautical Sciences, Sept 8-13, Madrid, Spain. Institute of the Aeronautical Sciences, 2 E 64 St, New York 21, N. Y.

Société des Radioélectriciens, International Symposium on Nuclear Electronics, Sept 16-29, UNESCO House, Paris, France. Colloque International "Electronique Nucléaire," 10, ave Pierre-Larousse, Malakoff, Seine, France.

Hot Laboratories Division Solicits Conference Abstracts

The Hot Laboratories Division of the Brookhaven National Laboratory would appreciate the early receipt of abstracts of papers that are to be presented at the 7th Conference on Hot Laboratories and Equipment. The abstracts are due September 15, 1958, at the latest.

These should be sent to the program chairman, L. G. Stang, Jr., Brookhaven National Laboratory, Upton, N. Y.

The deadline for the papers themselves will be announced later.

Papers are invited on all phases of hot laboratories and equipment for handling radioactive material including design, construction, operation, maintenance, decontamination, remodelling, shielding calculations, costs, etc.

The Conference will be held April 1959 in Cleveland, Ohio.

Install Indoor Electrical Substation

A 33,000-volt electrical substation, the first of its size ever installed indoors in the Philadelphia Electric Company service area, is now in operation at the Collegeville, Pa., plant of Superior Tube Company. Its inside location permits future expansion of the physical plant in any direction without moving the substation to make room for new construction. Located in the basement of Superior's large mill, the substation doubles the plant's transformer capacity. Both it and the company's first substation, located outdoors on the west side of the plant, have three 500-kva transformers. The new substation has a General Electric indoor ACB drawout switchgear to distribute power to various parts of the plant.

Installing the substation indoors required special safety measures. The wires from the 33,000-volt primary line were sheathed in lead and brought underground into the basement location. The most difficult problem was to provide ventilation to cool the transformers while making provisions to contain and put out transformer fires should they occur.

The firm's engineering department designed and built a special concrete block vault to house the three transformers. Cooling air blows into the vault through a screened opening in one wall, over the transformers and through a duct opening in the opposite wall and then to the roof.

For fire protection purposes, heavy metal slats, resembling a Venetian blind, are installed inside the opening through which the air enters. They are held open with a chain, one link of which is made from metal with a low melting point. If fire breaks out, the link instantly melts, and the metal slats close to seal off the opening. With the air supply cut off the fire quickly dies out.

The new substation installation has been approved both by the Philadelphia Electric Company and the Factory Mutual Fire Insurance Companies.

Linden Station Generates 450,000 Kw

Gov. Robert B. Meyner, members of the New Jersey Public Utility Commission, State and municipal officials, and many leaders in industry, commerce, and finance in New Jersey were guests of the Public Service Electric and Gas Company (PSEG) at the formal opening of its new $100 million Linden Generating Station located on the Arthur Kill in Linden, N. J.

Speaking to the group before embarking on a tour of the station, Gov. Meyner commended PSEG for its outstanding contributions to the welfare of the State of New Jersey and for its vision and foresight in constructing Linden Station. He pointed to the company's growth since the end of World War II, increasing its electric generating capacity over 100%, and said "this is an outsanding achievement."

NEWEST ADDITION to the electric system of the Public Service Electric and Gas Company is the Linden Generating Station, which consists of two 225,000-kw turbine-generators. Water treatment equipment can be seen in the foreground.

He also stated that PSEG, through the years, has embarked upon these remarkable investment, construction, and production programs which add considerably to the vitality, strength, and growth of the State. PSEG was also cited for its industrial development and advertising programs that have been an effective force in the attraction of new industries. The support and co-operation of PSEG with public agencies, State and local, were also mentioned in the Governor's speech.

The availability of adequate electric power not only to meet the present needs of residential, commercial, and industrial customers, but also to provide for expansion and advancement, has been an important factor in the company's growth in New Jersey over the years. It was stated that one of the major reasons for industries' contemplating the location of a new plant or the expansion of an existing one in New Jersey is the fact that dependable electric power is available in ample supply.

A unique feature of Linden Generating Station is the fact that it supplies large quantities of process steam by direct pipelines to the Bayway Refinery of the Esso Standard Oil Company, which adjoins the station. In exchange, the refinery supplies the station with fuel and water, also by direct pipelines. As a result, it is expected that Linden will operate at an economy which will surpass that of any large steam-generating station of advanced design now in service or under construction in the United States. The refinery obtains all of its electric energy from the PSEG transmission system.

Since the end of World War II, two new stations have been built and additional machines installed at existing stations, so that at present PSEG has a total generating capacity of about 2.5 million kw.

To take care of further growth in the immediate future, at present the company has under construction two more generating stations—Bergen and Mercer. Upon completion of the Bergen and Mercer installations, the total effective generating capacity of the company's eight stations will be more than triple the capacity at the end of World War II. All of these electric generating stations are interconnected.

Research in Neutron Decay Advanced

Scientists of the Argonne National Laboratory, Lemont, Ill., and the University of Chicago have discovered new facts about a fundamental nuclear process—the radioactive decay of the neutron. They have helped establish that two of the five possible types of interactions which cause neutron decay are the most important in the process, and that the signs of these two interactions are opposite. The relative signs of interactions have significant effects on observed experimental results in the beta decay of neutrons and nuclei.

A spokesman for the research team, Dr. G. R. Ringo, explained: "The long-range objective of our neutron decay experiments is to improve our understanding of the fundamental interactions of particles, which in turn helps us to understand more about the basic nature of matter. There is some chance we will eventually be able to stimulate radical revision of fundamental theory."

The radioactive decay of the neutron is one of the most basic of nuclear processes. A University of Chicago–Argonne research team last year proved, with the aid of an Argonne nuclear reactor, that the law of "parity conservation," formerly a basic assumption among physicists, does not apply in the radioactive decay of the neutron.

Work on the latest set of experiments was done from November 1957 to April 1958. "Slow" neutron beams streaming out of Argonne's Chicago Pile 5 (CP-5) research reactor were used. Measurements were recorded on special equipment designed, built, and installed at Argonne's site near Lemont, Ill.

Dr. Ringo pointed out that the neutron, as it decays, emits three particles, the beta

(or electron), the proton, and neutrino, or "little neutron." The beta and proton particles are detectable, but the neutrino is undetectable. Scientists know that it serves as an invisible balancing force in the decay process.

After a series of experiments in which the neutrino directional emission correlation was separated from the beta directional emission correlation, it was found that: (1) neutrino emission has a strong positive directional correlation to neutron "spin," while beta particles have a weak directional correlation, and tend to be emitted opposite to the direction of the "spin"; (2) three of the five possible types of interactions in neutron decay are not important to the process; and (3) the two types that are important have opposite signs.

There are apparently four basic types of interaction between particles of matter: gravitational, weak, electromagnetic, and nuclear. Gravitational interaction refers to the pull of gravity. Examples of weak interaction are neutron decay, and decay of some of the so-called "strange" particles —tiny nuclear fragments produced in giant atom smashers that blast apart atomic nuclei. Some illustrations of electromagnetic interaction are the emission of light rays, radio waves, gamma rays, and X rays. Nuclear interactions, the strongest of all, refer to the forces that bind together the tight package of protons and neutrons known as the nucleus of an atom.

The neutron can be thought of as a tiny magnet spinning on an axis that runs from its north to its south poles. The fallacious principle of parity led to the deduction that electrons produced by neutron decay would be emitted in equal amounts toward both poles. The first joint series of University of Chicago–Argonne experiments on the radioactive decay of the neutron showed that the parity law also failed in neutron decay. Then the scientists extended their experiments, and obtained the current results which provide further information about the polarized neutron decay process.

Reactor Developments and Nuclear Technology Briefs

Weapons Testing. Regulations prohibiting entry into the Eniwetok Proving Ground Danger Area have been issued for United States citizens and all other persons subject to the jurisdiction of the United States, its territories, and possessions. Effective from April 11, 1958, until the end of the Hardtack test series, it prohibits entry, attempted entry, or conspiracy to enter the area designated by a series of longitudinal and latitudinal readings which are available in the release from the AEC Title 10, Chapter 1, Part 112, February 14, 1958.

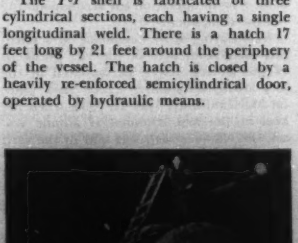
Nuclear-Powered Merchant Ship. The Maritime Administration, U. S. Department of Commerce, and the AEC invite shipping firms to submit expressions of interest in operating the world's first nuclear-powered merchant ship, the *N.S. Savannah.* In order to provide the ship with a highly trained and competent crew, a training program schedule has been established, with a reporting date for licensed engineering officers on or about September 1, 1958, and a crew after that, as necessary.

Euratom Discussions. A joint United States–European Atomic Energy Community (Euratom) working party convened in Luxembourg on March 20, 1958, instructed to pay special attention to the possibility of initiating a joint program for the development of full-scale prototype power reactors. The meeting also discussed the possibilities of close cooperation between the groups in order to develop the peaceful uses of atomic energy in the fields in which Euratom will be engaged.

Nuclear-Powered Aircraft Engine Testing. A massive test chamber to be used in the development of nuclear-powered aircraft engines will use *T-1*, a high-yield-strength alloy steel produced by Lukens Steel Company, to gain important savings in fabrication and transportation costs. It is nearing completion in Boston, Mass., in the fabricating shops of O. G. Kelley & Co.

The vessel will weigh only 160 tons when installed at the CANEL Project (Connecticut Aircraft Nuclear Engine Laboratory) in Middletown, Conn. Its job: to permit tests on experimental nuclear aircraft components.

The *T-1* shell is fabricated of three cylindrical sections, each having a single longitudinal weld. There is a hatch 17 feet long by 21 feet around the periphery of the vessel. The hatch is closed by a heavily re-enforced semicylindrical door, operated by hydraulic means.



CRAMPED-AREA interior welds were no problem for Paul Young (in opening) as work neared completion on this massive Lukens *T-1* alloy test chamber. He stands 38 inches tall in his safety shoes and is believed to be the world's smallest welder.

The entire test chamber (excluding internal insulation and stainless-steel liner) was heat-treated in a 50 by 20 by 20 foot gas-fired annealing furnace specially built for this purpose.

Alloy Reduces Nuclear Power Costs. The Argonne National Laboratory of the Atomic Energy Commission (AEC) has developed an aluminum alloy which is expected to help reduce the cost of producing nuclear power.

Alloy *X-8001*, the fuel element cladding, was developed by adding small amounts of nickel to aluminum 1100, a commercial alloy which contains iron. The addition of nickel made *X-8001* much more resistant to corrosion by high temperature water than commercial aluminums having iron as the primary alloy material.

The development of *X-8001* may be an important factor in production of economic nuclear power in the future.

When Is a Barn Not a Barn? Answer: when it is used as a scientific term.

"Barn" is one of the most important terms in nuclear science, but few persons know how it came to be used.

An Argonne National Laboratory physicist—Dr. Lowell Bollinger—decided to track down the story. After an exchange of letters with colleagues in the East, Dr. Bollinger was able to reveal how "barn" joined the world of science.

"Barn" is the name given to a unit of measurement for the target area of a nucleus (the center of an atom); that is, the area presented by the nucleus to an incident particle.

One of the primary methods of learning more about the atom is to bombard it with "bullet" particles, and study the effects. The target area is usually the nucleus—a tightly bound package of protons and neutrons. Projectile particles striking the nucleus may produce fission, or scattering, or they may be captured.

Scientists use the phrase "cross-section" to describe the probability of hitting a nucleus with "bullet" particles, and the probability of producing one of the aforementioned reactions if the nucleus is hit.

The term "barn" is the basic unit of cross-section area measurement. A "barn" is defined as an area of 10^{-24} square centimeters. The size of an atom is calculated at 10^{-16} square centimeters. A nucleus larger than 10^{-24} square centimeters has a greater area than one barn; a nucleus smaller than this figure has a lesser area than one barn.

Following is the story told in a reply to Dr. Bollinger's letter asking about the origin of the term.

Early in 1943, a group of scientists was working at Purdue University on cross sections. They had found in their calculations that 10^{-24} square centimeters was a natural unit of measurement for the cross-sections, and decided to give the unit some name, for their notes and convenience. The group included C. P. Baker, M. G. Holloway, L. D. P. King and R. E. Schreiber.

Baker had dinner with Holloway one evening, and they discussed various names. Many they came up with were either already being used, or were too long. For instance, "Oppenheimer," "Konopinski," and "Bethe" would have led to confusion.

Dr. Baker wrote, ". . . We thought that possibly a first name might work. The first suggestion was 'John,' with the added suggestion that the large slow neutron cross-sections might use the prefix 'brick' instead of 'kilo.'

"That got us out of doors, and just looking around, there was a barn. Why not? The side of a barn was an established target area. And Bethe had told us that if the cross-section were as large as 10^{-24} square centimeters 'it would be very big indeed.'"

The scientists started using the term among themselves, and were surprised to find that it was an established unit by Autumn 1948. It appeared in the *Physical Review* (a major scientific publication), and won general acceptance in all scientific circles.

Zero Gradient Proton Synchrotron. An architect-engineer has been named by the Argonne National Laboratory for design work in connection with the 12.5-billion electron-volt zero-gradient proton synchrotron to be built at Argonne's main site near Lemont, Ill.

The new Argonne machine will produce greater numbers of accelerated particles than any other of the multibillion electron volt accelerators now in operation or under construction anywhere in the world. It will be the largest basic research tool of its type ever built in the Middle West.

Argonne's particle accelerator will be housed in an earth-covered tunnel 200 feet in diameter. The supporting facilities will include about 10 laboratory and auxiliary structures.

The architect-engineer contract covers the design of buildings and normal building services. Certain other work will be done jointly by Argonne and the architect-engineer, including connections with plant utility services.

The particle accelerator will have a doughnut-shaped magnet installed within the earth-covered tunnel. Weighing approximately 4,000 tons, the accelerator's magnet will be 10 feet wide and 6 feet high. It will be constructed of laminated steel plates stacked against one another vertically and insulated from each other.

American Nuclear Society Moves. Chicago, the birthplace of nuclear energy, soon will be the new home of the American Nuclear Society (ANS) which moved its headquarters from Oak Ridge, Tenn., to the John Crerar Library, 86 E. Randolph St., Chicago, Ill. It is one of the world's largest technical libraries, and an official U. S. AEC repository for literature on atomic energy.

The ANS sponsors two meetings of its own annually for experts interested in atomic energy. Together with more than a score of other engineering and technical societies, it plays a primary role in arranging the technical program for the annual Nuclear Congress.

Incorporated in New York in January 1955, the ANS has approximately 3,000 members. It is the only professional society concerned with the entire range of nuclear science and engineering.

The main objectives of the American Nuclear Society are advancement of nuclear science and engineering, of allied sciences and arts, and the integration of the several disciplines constituting nuclear science and technology.

Other objectives include encouragement of research, establishment of scholarships, dissemination of technical information, holding of meetings devoted to scientific and technical papers, and co-operation with government agencies, educational institutions and other organizations having similar purposes.

Senior Scientist Rank Appointments. The appointment of nine Argonne National Laboratory scientists to the rank of senior scientist has been announced by Dr. Norman H. Hilberry, Laboratory Director.

Dr. Hilberry said the nine men are: P. R. Fields, L. E. Glendenin, G. R. Hennig, J. R. Huizenga, Bernard Smaller, E. P. Steinberg, R. J. Thorn, and P. H. Yuster, all of the Chemistry Division, and M. H. Foss of the Particle Accelerator Division.

Engineering Test Reactor Operates at Design Power Level. The Nation's largest and most advanced nuclear test facility—the Engineering Test Reactor—has attained full design power at the AEC's National Reactor Testing Station, Idaho Falls, Idaho. The test reactor began operating at the design power level of 175,000 kw of heat at 10:27 p.m. on April 19, 1958.

The ETR is expected to play a key role as a research tool in the development of economic nuclear power. It will be used to test the effects of intense neutron and gamma ray bombardment on the engineering components of reactors under design. Through use of the ETR, the extent of nuclear "wear and tear" that would ordinarily occur only after years of normal reactor operation can be determined in weeks or months. The ETR's average neutron flux is 1.9 million billion neutrons per square centimeter per second. Its test spaces, measuring up to 9 x 9 x 36 inches, are the largest in any test reactor now in operation for accommodating reactor components.

Keel Laying of NS Savannah. Mrs. Richard M. Nixon, wife of the vice-president of the United States, participated in the keel-laying ceremonies which took place on Maritime Day, May 22, 1958, when the keel of the first commercial atomic vessel, the *NS Savannah* was laid in the yard of the New York Shipbuilding Corporation, Camden, N.J. Other honored guests were invited to the ceremony in which the world's first nuclear-powered ship, named in honor of the *SS Savannah*, first steamship to cross the Atlantic Ocean, was started.

The old *Savannah* was a three-masted, full-rigged ship with a one-cylinder, 90-hp engine. She was 100 feet long. On her historic voyage the *Savannah* could carry only enough coal to drive the engine 90 hours of the 29½ day trip from Savannah to Liverpool. Much of the time the ship traveled under sail. In contrast, the nuclear ship *Savannah* will be a combination passenger–cargo vessel, 585 feet long and 78 feet wide, capable of carrying 60 passengers, a crew of 100, and 10,000 tons of cargo at a speed of 20¼ knots, for 2½ years without refueling. The reactor, which is being built under the supervision of the AEC by Babcock and Wilcox, will use a pressurized water system of advanced design.

Army Signal Corps 98th Anniversary Celebration

Keynoting its 98th Anniversary on June 21, 1958, the U. S. Army Signal Corps featured the forward strides of its research and development program.

The anniversary was observed on a world-wide scale by all Signal Corps installations and troop units. Open house events, demonstrations, displays of Signal Corps communications and electronics equipment, personal appearances of Corps personnel on radio and television, troop reviews, and social events all enhanced the anniversary celebration.

U.S. Army Photograph

RADAR MORTAR LOCATER, which can spot location of enemy mortar fire, is set up in field by Pvt. Edward Rhodes (left) and SP3 Samuel Humes. The new finder, developed at the Signal Corps Engineering Laboratories, is built by General Electric Corporation of Syracuse, N. Y. Pvt. Rhodes is adjusting scanner before operation; and SP3 Humes is emerging from hood covering operating console on which rapid reading of enemy's mortar location is made. Thus, a commander can direct artillery fire on the mortar site in a matter of seconds.

Prominent portrayal of its research and development work dramatized the anniversary activities. Through its vast research and development program the Signal Corps is constantly increasing the combat effectiveness of the U. S. Army as well as seeking ways of improving the American standard of living.

The commemorative message of the Chief Signal Officer, Maj. Gen. J. D. O'Connell, USA, stated:

"The 98th Anniversary of the Army Signal Corps which we commemorate on the 21st of June marks the close of another period of progressive achievement toward our singular goal of military preparedness—and the beginning of another year in the service of national security.

"While we emphasize, this year, our tremendous advances in research and development, the Army Signal Corps can rightfully be proud of our collective contributions and distinguished accomplishments in all fields of endeavor.

"To all of you—military and civilian—I extend my warmest personal wishes on this anniversary. I commend you for your zeal and industry in the past, and look confidently with all of you to the future."

Brig. Gen. E. F. Cook, Chief, Research and Development Division, stated that the Signal Corps anniversary finds national attention focused on science for defense more than at any other time in peacetime history. And the art of war, which once needed little more than a strong arm and an elemental application of tactics and strategy, has become truly scientific . . . Electronics is as necessary to military operations as ammunition; in fact it is

a prerequisite . . . Nuclear or not, hot or cold, modern warfare must be electronic. Electronic combat of the future will extend far beyond the narrow concepts of the present . . . Much work is also done in fields that are not strictly electronic. Wire and insulation are constantly being improved; meteorology is a major Signal Corps field. So is photography. But even in these apparently unrelated fields, electronics enters. Wire communications are improved by such elements as electronic repeaters. High-altitude weather studies would be impossible without radar and radio tracking of balloons and rockets, and electronics gave us the stroboscopic lighting making much of today's high-speed photography possible . . . To achieve its outstanding record, the Signal Corps maintains one of the world's largest electronics laboratories at Fort Monmouth, N. J.

Every effort is being made to increase communication speed by substitution of electronic for human reaction time . . . Electronic computers will be able to exchange data with each other, their automatic programming permitting rapid changes of machine routine when a command desires . . . Computer applications to the problems of the military are endless. In logistics, the inventory and assignment of personnel and material becomes almost instantaneous . . . Further fields of computer capability—trajectory, meteorology, and burst area—are of vital concern to commanders who sometimes are far removed from the mud of infantry combat zones . . . First cousins to missiles are artificial satellites, blasted into orbit by missiles . . . One excellent example is found in the Explorer I satellite now circling the globe. This satellite contains a Geiger tube that measures cosmic rays, the tube requiring 700 volts of electricity with extremely precise limits. The batteries available in the Explorer I, developed at the Signal Corps Laboratory, produce between 4.5 and 5.5 volts. To make the Geiger tube work, it was necessary to provide an extremely light power converter

U.S. Army Photograph

DISH-SHAPED ANTENNA automatically tracks balloon, computers stamp out vital pressure, humidity, temperature and wind readings as "brainy" weather machine—electronic computers, arranged as battlefield console—automatically figures high-altitude weather reports from information radioed down by balloon-borne weather station. The system was developed and designed by the Signal Corps Engineering Laboratories. Two members of the Corps are operating the system.

that would jump the voltage from the variable input to a precise 700-volt output . . . Prior to the first proposed Vanguard firing and the actual Explorer I launching, the giant Space Sentry transmitter at Fort Monmouth beamed powerful 108-mc radio pulses at the moon. The signals bounced back to the widely scattered Minitrack stations set up to receive satellite signals, permitting them to calibrate precisely their tracking instrumentation.

These recent advances, in addition to playing a vital part in long-range military superiority, have provided many civilian benefits. They have made possible better home and beach radios, improved batteries and tubes, more reliable television sets, and, in general, have boosted the quality of almost all commercial electronic devices.

Society for the History of Technology

Interested scholars from institutions and universities around the country have formed a research group to assess the impact of technology on society. The Society for the History of Technology will sponsor meetings at which various aspects of technological history will be investigated.

As the first of these meetings, the Society cosponsored the meeting of the Humanistic-Social Division of the American Society for Engineering Education, at the University of California, Berkeley, Calif., on June 16-17. The program included reports by Robert Multhauf, head curator, Science and Technology, Smithsonian Institution; T. S. Kuhn, University of California; C. W. Condit, Northwestern University; and Edward Lurie, University of Michigan.

The Society expects to begin publication of a journal, "Technology and Culture," in the Fall of 1959, which will be devoted to the study of the development of technology and its relations with society and culture.

Applications for charter membership ($10) in the Society should be sent to its Chairman, Professor Melvin Kranzberg, Room 315, Main Building, Case Institute of Technology, Cleveland 6, Ohio.

What Holds the Atomic Nucleus Together?

High-frequency electromagnetic forces hold together the fundamental particles of the atom. These particles number at least 28, are of varying masses, and in some instances are related in ratios almost as simple as 2, 3, 4.

This thesis, a proposed answer to one of the basic riddles of physics, was offered before a meeting of The New York Academy of Sciences by Dr. J. J. Grebe, director of nuclear and basic research for the Dow Chemical Company, Midland, Mich.

What Dr. Grebe reported he has done, shorn of mathematics, is to construct a periodic table of fundamental particles—the electron, positron, mesons, neutron, proton, and hyperon—similar to the periodic table of the elements which is familiar to all high-school chemistry students.

The basic particle in Dr. Grebe's table is the electron, with a negative charge, or the positron, with a positive charge. He suggests that all other, larger particles are made up of multiples of combinations of these two.

Dr. Lyle Borst, chairman of the Academy's section of Mathematics and Engineering, explained Dr. Grebe's achievement, if confirmed, as of transcendent importance.

Asked whether the concept might reconcile the field and quantum theories, the basic conflict of modern physics, Dr. Borst said: "Dr. Grebe has gone so far beyond anyone else—he has taken such a tremendous leap into the unknown—that it is not possible to predict at this time where this will lead. It may result in reconciliation of the field and quantum theories. It may supplant them both. It may, as Dr. Grebe pointed out in his paper, be discarded. But, even if discarded, it will have contributed to the eventual explanation of the structure of matter."

Dr. Grebe's explanation stems, his report stated, from a 40-year study of the problem, and from a conviction that complicated explanations are uncalled-for because "nature is so beautiful and orderly and ultrasimple."

His search for a simple concept led him to study the relations to be found among the fundamental particles, which fall into 12 distinct size groupings.

He reported that, "Among hundreds of geometric relations studied, two key ratios were found that ultimately sprang the door." These are the ratio between the mass of μ mesons, 206.86 ± 0.11, and that of π mesons, 264.37 ± 0.6, and the ratio between the proton, $1,836.12 \pm 0.04$, and the σ hyperon, $2,342 \pm 1.5$. Each proves to be π (3.1416) over 4.

From this ratio, Dr. Grebe derived a constant, 1.12888. This figure is the basic mathematical value in his table. To it he has given the name "g."

In the table Dr. Grebe has constructed, the electron and positron, the basic particles have the same value, g^0.

The μ meson has a value of g^{44}.
The uncharged π meson equals g^{46}.
The K mesons, halved, equal g^{51}.
The charged π mesons, doubled, g^{52}.
The neutron, g^{62}.
The σ meson, g^{64}.

The most stable of the larger particles, Dr. Grebe pointed out, appear to be the μ mesons, the π mesons, and the neutron, with exponents (or g powers) of 44, 52, and 62, respectively, whose squares are in the ratio of 2, 3, 4 to one another. "These," he explained, "if used as the three dimensions for a solid of fixed shape, would still require an additional variable to make it possible to match the corresponding masses. This variable can be a time-related function, such as velocity."

Inertia and gravity, as aspects or effects of electromagnetic forces, also enter into Dr. Grebe's hypothesis. His report suggests: "Visualize inertia as that acceleration

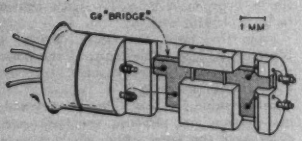
of an already rapidly moving body that occurs when matter consisting of a whole set of gyroscopes, geared to a synchronous field, is accelerated still more with respect to that geared and meshed grid of electromagnetic standing waves providing gravitational forces.

"It will then be easy to understand why gravity cannot be shielded and yet operates with the law of electromagnetic attraction. For still more complete and realistic explanations, one can express the entire process with the electrostatic equations of forces."

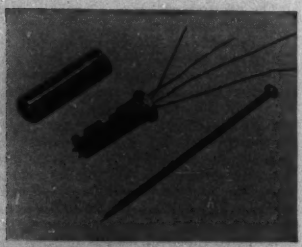
And he adds: "The whole picture of the conversion of energy to matter by pair formation known for 30 years and the annihilation of matter into energy so ably demonstrated at Berkeley during the last few years, becomes familiar because of our long association with the production and decay of elemental charges. It gives one great confidence to know that the only indivisible matter we have dealt with appear to be the electron and the positron, 1,836.12 times lighter in mass than that paragon of stability, the proton, the nucleus of hydrogen."

Germanium Resistance Thermometer

A germanium resistance thermometer having high sensitivity and exceptional stability in the temperature range near absolute zero has been developed by J. E. Kunzler, T. H. Geballe, and G. W. Hull of Bell Telephone Laboratories, located at 463 West St., New York, N.Y. Once calibrated, this thermometer is reproducible to better than a few ten thousandths of a degree at the boiling point of helium (4.2 degrees K) even after repeated cycling from room temperature. Such characteristics indicate that this thermometer might be useful for the accurate measurement of temperatures in outer space, when mounted in a suitable space vehicle.



CROSS-SECTION drawing showing internal construction of the germanium resistance thermometer.



GERMANIUM RESISTANCE THERMOMETER developed at Bell Telephone Laboratories, compared in size with a common pin.

Continued emphasis on low-temperature research has highlighted the need for a thermometer which would indicate low temperatures accurately and reliably, and would not need continued recalibration. Such a device would be of great help in low-temperature calorimetric work. The germanium resistance thermometer meets these specifications.

The heart of this thermometer is a very small "bridge" cut from a single crystal of arsenic-doped germanium. Actual size of this bridge is about 0.025 inch x 0.020 inch x 0.210 inch. Current and potential leads are attached to the bridge, and it is supported in a strain-free manner in a platinum-glass enclosure containing a small amount of helium gas to aid in thermal conduction. The resistance is determined by measuring the potential drop when a small (approximately 10 microamperes) known current is passed through the bridge.

Germanium can be doped with arsenic to produce a high and fairly constant temperature coefficient of resistance at temperatures near the boiling point of helium. For example, a typical thermometer made at the Laboratories had a resistance of about one ohm at room temperature, 14 ohms at 10 degrees K, and 216 ohms at 2 degrees K. Both the temperature coefficient and the actual resistance vary widely with minute changes in the amount of doping, making it possible to fabricate a thermometer having any of a wide range of characteristics. Such a thermometer will retain its calibration despite repeated cycling from 300 degrees K to 1 degree K.

To avoid excessive heating when measurements are being made, the resistance of the thermometer should be kept as large as possible. However, for simplicity in measurements, a low resistance is desirable. For a specific application, a compromise can be reached by controlling the doping of the germanium crystal.

These resistance thermometers are not available from Bell Telephone Laboratories, but a number of them are being turned over to the Calorimetry Conference for testing. If this Conference finds that they have wide usefulness, efforts will be made to interest a qualified manufacturer in making them commercially available.

All-Transistor Data-Processing Systems

Two commercially available all-transistor large-scale computer models, Transac *S-1000* and *S-2000*, were demonstrated recently. Designed by the Philco Corp., Philadelphia, Pa., for the use of scientific and industrial organizations in solving complex mathematical and data-processing problems, the computers incorporate features not found in conventional vacuum-tube computers. Both units plug into standard 110-volt 60-cycle outlets, consuming about 1/10 as much electricity as vacuum-tube computers; produce a minute amount of heat, requiring less air-conditioning equipment; and, because of miniaturization through the use of transistors, occupy less space.

The desk-size Transac *S-1000* features a 4,096-word magnetic-core memory which makes possible a speed of 180,000 subtractions and additions in 1 second. This core memory is contained in a box which is less than 1 cubic foot in size and is capable of memorizing and retaining 45,000 characters of information. The computer is capable of recalling one of these characters from the memory storage in 12 millionths of a second. Mounted on casters, the *S-1000* may be moved easily from one location to another.

Included in the characteristics of the *S-2000* are a 48 binary digit word length capacity and a 4,096-word core storage expandable to 65,536 words. Able to operate efficiently in the space of a small business office, the data-processing system operates from a magnetic tape bit formula which includes 16 channels, 12 information bits, 2 parity, and 2 timing. Tape speed is 150 inches per second. The Transac *S-2000* high-speed printer has a capacity of 900 lines per minute. A 1,024-character buffer permits extensive changes of format and data placement without repassing through the computer and control.

President of Welding Society Elected

G. O. Hoglund, head of the welding section of the Aluminum Company of America Process Development Laboratory, was elected president of the American Welding Society (AWS). He was officially presented to the membership at the opening ceremony of the 39th Annual Meeting of AWS held on April 14 at the Statler Hotel, St. Louis, Mo. The 6th AWS Welding Show was held concurrently at the Kiel Auditorium, St. Louis.

Mr. Hoglund's AWS activities include membership on the Board of Directors and past chairman of the Pittsburgh Section of the AWS. He has made many noteworthy contributions to the welding industry, and in 1939, he received the Lincoln Gold Medal for his technical paper on "Spot Welding the Aluminum Alloys."

High Vacuum Melting Technique

A process to melt and cast special metals, such as titanium, zirconium, tantalum, molybdenum, and columbium, has been proved on a semi-works scale. The technique was jointly announced by Stauffer Chemical Company, New York N. Y., Mallory-Sharon Metals Corporation, and Temescal Metallurgical Corporation, the three companies which have co-operated in its development.

The process uses electron bombardment in a high vacuum to melt chemically active materials which have high melting points. Techniques have been developed which make possible volatilization and removal

of certain critical impurities, resulting in final products of high purity with properties not attainable by other methods. The semi-works plant has successfully melted, purified, and cast a dozen special metals in water-cooled crucibles with no contamination from the crucible.

The immediate significance of the process is two-fold: (1) electron beam melting should stimulate development of the uses of newer metals because the process will make available, for the first time, commercial quantities of high purity material at substantially lower costs; and (2) in many cases it will permit recycling scrap, thus reducing loss, an important factor, considering the relatively high cost of many of these materials.

The process, conceived by Temescal, is based primarily on high vacuum techniques. Heat for melting is supplied by an electron gun which serves as the cathode and bombards the melt stock (the anode) with electrons, heating it to the melting point. Molten metal drops into a water-cooled copper crucible below, in which the heat required to maintain a molten pool is also provided by electron bombardment. The molten-pool surface is kept at a constant level as the solidified ingot is withdrawn downward.

The electron beam process can be stopped and started at any time and can melt material in any form, e.g., ingot, powder, flake, or sponge. It differs in principle from vacuum arc melting not only in the heating mechanism (high-voltage electron bombardment rather than a low-voltage electric arc) but also in the level of vacuum used which is in the range of 0.01 to 0.1 microns rather than 10 to 100 microns. Under the conditions existing in the furnace, carbon, hydrogen, and oxygen generally are removed rapidly as carbon monoxide, metal oxides, or similar compounds. As a rule, impurities which form compounds having a vapor pressure of at least 10^{-5} atmospheres at the surface of the melt can be removed easily.

The process can also be used for zone refining. One big advantage of electron beam melting is that there is no apparent limitation on the diameter of the bar or ingot that can be processed. Hence, electron-beam-melted materials can be purified faster and cheaper because a larger quantity of metal can be turned out at a given time.

Tantalum, molybdenum, and other metals have been produced of higher purity than ever known before. Ductile columbium, previously only a laboratory curiosity made by solid-state sintering, is now a commercial reality; for example, a 1/2-mil columbium foil has been made from a 3-inch ingot by cold rolling without annealing. This achievement was impossible until electron bombardment melting produced a high-purity ingot.

AMB Selects Site for Experimental Center

Selection of Atlantic City, N.J., as the site for a proposed National Aviation Facilities Experimental Center (NAFEC) was announced recently by E. R. Quesada, chairman of the Airways Modernization Board (AMB).

The site was selected by unanimous decision of Board members M. A. MacIntyre, Under Secretary of the U.S. Air Force, L. S. Rothschild, Under Secretary of Commerce for Transportation, and Mr. Quesada. It was considered the optimum solution in choice of a place for testing tomorrow's civil-military air traffic management system. The site is the Atlantic City Naval Air Station. It is also used by the airlines for scheduled flights.

Since August 1957, the Board has sought a site for the Center where intricate problems of procedure and equipment needed to modernize the Nation's civil and military air facilities could be formulated and solved by teams of scientists, pilots, air traffic controllers, and engineers working in an environment that has both simulated and real traffic.

To meet this goal, AMB examined over 1,800 existing airports for a potential site. The Board was confronted with the diverse requirement of free airspace on one hand, and the realities of a high density traffic situation on the other. By selecting Atlantic City as a site, the Board will have available the relatively free and open area of the Atlantic Ocean to the east, and the complexities of coping with high traffic density to the west.

The site permits the following user groups to participate actively in the efforts of the Board: commercial, general aviation, and military including carrier-based naval aircraft.

Also needed was an all-weather site where the extremes of dense fog and clear weather, cold and hot weather, and heavy storms and calm conditions would be encountered.

Another prime factor was proximity to the first SAGE (semi-automatic ground environment) Center used by the U.S. Air Defense Command for air defense control. Modernization of the Nation's aviation facilities calls for exchange, among other things, of air traffic control data between civil and military centers since the system must accommodate both types of traffic in peace or war.

The Atlantic City site meets these requirements among others, and Mr. Quesada said he expects that occupancy and operation of the Center could begin by July 1, 1958, subsequent to successful negotiation with the City of Atlantic City and other agencies and parties involved.

The selected site offers, among other things, capability for early start of experimentation. The existence of buildings and other facilities will permit immediate occupancy and the orderly development of future facilities as the AMB requirements are defined.

The Board has had the benefit of complete co-operation of the Civil Aeronautics Administration, and the Navy with respect to feasibility of transferring facilities and equipment at the Naval Air Station, Mr. Quesada said.

The AMB plans continued operation of the airport to accommodate airline and general aviation traffic.

No new restricted areas would be required which put additional burdens on our already capacity-limited system, Mr. Quesada said.

Ultraminiature Electronic Device

EXPERIMENTAL shift register transistor, only ½ inch long and 0.004 inch thick (shown under magnifying glass), developed at RCA Laboratories, Princeton, N. J., represents anticipated advance in miniaturization. After further development, it is expected to perform functions now requiring circuit arrangement of 20 transistors, 40 resistors, and 20 capacitors. At upper left is a testing unit for the device. At lower right are elements of capsule in which an experimental unit is enclosed for testing.

Fiscal requirement for the first year of Center operation has been set at approximately $12 million. According to AMB's site selection evaluation team, selection of Atlantic City permits utilization of a substantial existing capital investment.

Present AMB programming calls for a total Center population of 225 professional and technical AMB personnel during fiscal year 1959. These would be scientists, military officers, and engineers.

Manned Craft To Probe Outer Space

The *X-15*, which will fly man higher and faster than he has ever been, will actually glow red as it plunges back into the earth's blanket of air, resembling the iron in a blacksmith's forge.

Built of new stainless steel alloys to combat these high temperature conditions, the research vehicle is now being assembled at North American Aviation's (NAA) Los Angeles, Calif., plant. It is expected to make its first flight from Edwards Air Force Base early next year as a joint project of the U.S. Air Force, Navy, and National Advisory Committee for Aeronautics.

In *Skyline*, an NA magazine released to employees, the *X-15* was described as a "pencil-thin ship with wings like cleaver blades and which has stubs of control surfaces and a ventral fin."

"The importance of the *X-15* is not only in its role as the first manned craft to probe outer space," the magazine pointed out. "Manufacturing techniques now being worked out on the new metals will set the pattern for future families of airplanes."

Harrison Storms, NA chief engineer,

said that the solving of heat problems is the key to the *X-15* design. "Temperatures ranging down from about 1,000 F to 500 F below zero—that of its liquid oxygen—will be encountered by the airplane," he declared.

"The *X-15* will get as hot as would a normal size bedroom with 80 home floor furnaces going full blast in it!"

Storms said the speed of the *X-15*, which is better than one mile a second, would permit it to fly from New York to Los Angeles and land two and a third hours *before* it took off. The pilot could eat lunch and arrive on the West Coast in time for a late breakfast.

Special controls will permit the pilot to keep the *X-15* on course with wrist motion only because his arms will be pressed tightly into his seat by the tremendous forces encountered. To keep the airplane in its proper attitude during its flight above the atmosphere, hydrogen peroxide jet streams in the nose and wingtips will be used for the first time. Acting just like jets of steam, they will push the plane in the opposite direction to their force.

Because the flight path of the *X-15* is expected to take it at least 100 miles high, there can be no explosions once it leaves the earth's atmosphere as there is not enough oxygen to support combustion.

In the event of an emergency, the entire cockpit can be utilized as a built-in "escape capsule." This insulated area protects the pilot from the scorching heat of extreme speed and, should his cabin lose its pressure, a tailor-made "space" suit encloses him in a normal pressure and atmosphere environment.

Flown first by North American test pilot Scott Crossfield, the *X-15* later will be turned over to the Air Force and NACA where such pilots as Korea Jet Ace Capt. Iven C. Kincheloe, Jr., and NACA Chief Tester Joe Walker will put it through its paces.

Experimental Radar Research Plane Designed

The U.S. Navy unveiled for a first public showing an experimental "flying saucer" radar research airplane designed to bolster America's air defense perimeter by greatly improving the ability of sky sentinels to detect and warn of attack. It has been called "the strangest shape in the sky."

The huge aircraft carries the most effective known airborne radar equipment to altitudes from where its detection devices can patrol vast distances—from the fringes of space all the way down to the Earth's surface.

Built by Lockheed Aircraft Corporation, the *WV-2E* aircraft resembles a Super Constellation airliner with a discus-shaped saucer riding piggy-back.

Within its saucer—a 37-foot-wide radome which rotates during flight—is a supervision electronic "eye."

Pointing up the significance of the futuristic airplane and the vital role of airborne early warning in national defense, it was stated that nuclear-armed bombers constitute the most immediate threat to American cities and bases—and will remain a threat to our security and way of life for years to come.

Until its debut, the *WV-2E* had not been available for close-up viewing or interior inspection.

Lincoln Laboratories of the Massachusetts Institute of Technology played a key role in developing the electronic sentry's highly complex radar equipment.

The development engineer with Lincoln Laboratries reported that the experimental airplane came into being under the sponsorship of the Navy's Bureau of Aeronautics. Project direction was assigned to the Naval Air Development Unit, with Lockheed as the Airplane Design and Electronics Systems Manager, and General Electric and Hughes Aircraft as major suppliers.

Lincoln Laboratories was directly responsible for basic development of the new radar, designated *ARS-70* (Airborne Radar Search).

Important advantages of the saucer antenna and radar combination include: (1) sharp reduction of "sea clutter" interference, which sometimes partially clouds radar scope like visual static seen on television screens, and (2) ability to report on objects in the skies from sea level to 100,000 foot altitudes without shifting the antenna upward or downward.

Distinguished by a hump on the back and a bulge on the lower fuselage, the present Lockheed-built AEW planes are flying extended missions from Otis Air Force Base, Mass., McClelland Air Force Base, Calif., Barber's Point Naval Air Station, Hawaii, and Argentia Naval Air Station, Newfoundland. Other sister craft fly fleet sentry duty and serve as aerial combat centers.

For reasons of military security, certain key advances in the new airplane—which is aimed at lengthening and strengthening the nation's electronic life line—are still closely guarded.

Among military officers present for the *WV-2E*'s unveiling were high ranking officers from NORAD American-Canadian Joint Staff, and top representatives from NAS, South Weymouth and nearby Navy and Air Force installations.

The *WV-2E*'s interior looks as scientific as the control room of a space ship, with scopes, automatic plotters, navigational devices, computers and data processing equipment lining the fuselage.

Because the airplane is designed for protractive operation, it carries its own galley, bunks, and areas for off-duty relaxation.

The crew of 22 can be carried in the flying radar station.

Head Lamp Alignment for Production Line Use

A unique head lamp alignment system, developed by Performance Measurements Co., of Detroit, Mich., provides a new method of aligning head lamps on an automobile production line. Already adopted by one automobile company, Oldsmobile, the new system assures head lamp alignment accuracy well within manufacturer's specifications, which are more stringent than SAE recommended practices by a factor of at least two. In addition, the use of the system permits the lamp adjustment floor space to be reduced from the normally required 25 feet to 7 feet.

All types of dual 5-inch lamps may be aligned with the system, which is comprised of two units weighing 400 pounds each. With a moving line, 300 pounds of each unit may be made stationary. The system is adaptable to any production line and can handle up to 75 cars per hour. Using the head lamp light pattern to make the alignment, the system does not depend upon the lamp pads.

Large dials easily readable to 0.004 degree permit the operators to know not only the direction of adjustment, but the amount required. Thus, the operator adjustments become a standardized routine as the operator readily obtains a feel for the required adjustment of the lamp in operational use.

TWO ELECTRONIC GAUGING and testing machines (one for each set of head lamps) insure proper dual headlight system installation at Oldsmobile Division of General Motors Corp. Beams from the headlamps pass through the 18-inch lens to a series of electric eyes which transmit readings to the four large dials at the top of the instrument. These dials indicate any error in direction or power of each of the four head lamps. After necessary adjustments are made, a built-in searching circuit rechecks accuracy. If accuracy does not fall within specified limits, colored soap is automatically sprayed on the windshield; this indicates that the lights must be readjusted.

Because of the small number of components used in the system and the ease with which they may be replaced, serviceability and maintenance provide a minimum of down time. Standard industrial instrumentation is utilized. Limit switches, which are an integral part of the system, provide quality control and, at the discretion of the automobile manufacturer, can be used for automatic recording, signal marking, or completely automating the alignment operation.

Providing exceptionally durable and precise components such as servo-driven indicators with automatic calibration,

hermetically sealed photocells, and an 18-inch specially mounted lens, the head lamp alignment system is designed for continuous use on today's production lines.

Space Flight at 2 Million Miles an Hour

Space ships traveling at more than 2 million miles an hour, electricity produced without generators, and electric power transmitted without wires are all parts of the foreseeable future. So said several featured speakers on controlled thermonuclear power at the 46th annual convention of the Institute of Radio Engineers (IRE).

One session dealt with man's quest to reproduce the thermonuclear or atomic fusion reaction under controlled laboratory conditions. Heretofore, man has produced this reaction only in the explosion of hydrogen bombs.

According to W. H. Bostick, head of the department of physics, Stevens Institute of Technology, Hoboken, N.J., samples of plasma or ionized gas used in fusion experiments have already been accelerated to more than 300,000 miles an hour by both Western and Soviet scientists. Bostick said that vehicular speeds of more than two million miles an hour are possible if the mechanism which produces these speeds for plasmas is thought of as a plasma propulsion motor for space craft.

E. W. Herold of C. Stellarator Associates and RCA Laboratories, Princeton, N.J., pointed out that the nuclear fusion process makes it possible to extract energy directly in electrical form, whereas in present-day reactors energy is produced first in the form of heat and must then go through cumbersome heat-exchange equipment and generators to be converted into electricity. In the fusion reactor of the future, electricity could be produced directly from the motion of free electric charges. This could result in a revolutionary reduction in the cost and complexity of electric power generating stations.

Mr. Herold also stated that nuclear fusion may make it possible to transmit electric power from one region to another by radiation instead of by conventional transmission lines.

The most important advantage of the fusion process over the present-day fission reactors is that the fuel supply is derived from sea water and is virtually unlimited. In addition, the end products of the reaction are relatively uncontaminated, thus eliminating the difficult problem of getting rid of radioactive waste from atomic power plants.

4th International Automation Exposition

The products and services of the world's automation industry were exhibited at the 4th International Automation Exposition and Congress, held June 9-13 at the New York Coliseum. Representing about 200 separate companies or major subsidiaries, the displays of instruments, components, and assemblies occupied 50,000 square feet of exhibit space.

Presiding at the formal opening ceremonies, Prof. C. F. Kayan of Columbia University, New York, N. Y., honorary chairman of the Congress, introduced the representatives and officers of the various national and international groups participating.

Included in the Exposition were over 100 clinic sessions, 15 technical sessions, and, for the first time, the Military Automation Exposition, which consisted of exhibits showing products designed for military applications or produced to meet military type specifications.

Four of the technical sessions had the common theme of "Materials Handling as a Key to Industrial Automation." These were sponsored by the Materials Handling Division, American Society of Mechanical Engineers. Two conferences, one cosponsored by Manhattan College and the other by the Plant Layout Technical Workshop, were also scheduled.

READ System Increases Radar Range

An electronic Radar Echo Augmentation Device (READ) that will make any airborne vehicle visible for greater distances on radar sets has been developed by Temco Aircraft Corporation, Dallas, Tex.

Officials said the small device, called READ, could make a given radar set effectively track an object up to five or eight times farther than possible before the READ system is added to the airborne vehicle.

Its uses are many. Installed in jet fighters, for example, it would increase the radar echo given by such an aircraft, reducing the possibility of midair collisions that have been taking an increasing toll of lives. Installed in new missiles or target drones, it would make tracking possible for great distances, aiding in testing the missiles and helping fighter pilots track them.

Used on small target drones, the READ could make the craft appear as large as a potential enemy bomber, giving more realistic training to interceptor pilots.

Although it has wide civilian and military uses, the device itself is small—about the size of two bricks placed end to end. It can be fitted into existing drones, missiles, and aircraft in a relatively short time. Temco installed a set in a demonstration aircraft in less than three days.

In one version, the READ includes a cylinder about 3 inches in diameter, a flush-mounted antenna array, and three small boxes about the size of packages of cigarets.

One application of the READ could be installed in the *XKDT-1*, a transonic, rocket-powered target drone now being evaluated at the U.S. Naval Air Missile Test Center, Point Mugu, Calif. The *XKDT-1* and similar high-speed targets now present such a small radar image and go so fast that it is difficult for interceptor pilots to find them in time to get a "lock on" and make a firing pass. With the READ installed, the target could be located much sooner and would appear on the fighter's radar scope as large as a "bandit" bomber, making the training mission much more like actual combat "scrambles." No extra equipment would need to be added to the jet interceptors, which have low-power radar because of weight and space limitations.

Installed on commercial jets, the READ would give ample warning to other radar-equipped aircraft that another plane is in the vicinity, thus reducing chances of midair collision. It would also greatly increase the radar image given off by small personal aircraft, making them safer to fly in congested areas.

Analyze Data on Deep Sea Currents

Scientists at the Woods Hole (Mass.) Oceanographic Institution are analyzing extensive data on deep currents of the Caribbean Sea and the Atlantic Ocean gathered during a two months' cruise by the reaserch vessel *Crawford*. When considered with other Atlantic IGY data, this information will shed important light on the circulation of the Atlantic Ocean and particularly on the "age" of deep Caribbean water, according to officials of the Woods Hole research team. The Woods Hole effort is part of the National Academy of Sciences' International Geophysical Year Committee program to enlarge man's knowledge of the earth.

The six-man scientific party on board the ship, headed by oceanographer W. G. Metcalf, obtained more than 2,000 deep temperature measurements and an equal number of water samples which were analyzed for salinity, oxygen content, and other chemical constituents. The samples were obtained from the surface down to depths as great as 23,000 feet while the ship was stopped. In addition, some 357 temperature measurements were taken while the ship was under way.

Using the recently developed Woods Hole precision echo sounder recorder, the *Crawford* determined that the windward passage between Cuba and Haiti has a "sill depth" of 5,046 feet. Sills are submarine ridges connecting two land masses; sill depth is the distance from the surface of the water to the top of the ridge. This passage and the Anegada Passage in the Virgin Islands are the deepest sills leading to the Caribbean and prevent exchange between the coldest Atlantic water and the deep Caribbean water.

The echo sounder was constantly in use and obtained accurate bottom profiles along the entire track of the *Crawford*, ranging from Bermuda to the Virgin Islands to Venezuela, from Colombia to Haiti, Jamaica to Central America, back to Cuba and from there to Panama.

The observations made in the South Atlantic cruise of the *Crawford* would normally have taken almost two years to work up in the laboratory. Within three months of the finish of the cruise, however, the reports were completed and sent to the IGY Data Centers. This was made possible partly through the development of the Woods Hole shipborne salinometer

(formerly all water samples had to be brought back for titration) and the Woods Hole precision echo sounder recorder, but mostly because of extra work by the seven scientists on board the ship.

To date, more than 7,000 deep temperature and water samples have been taken as well as some 3,760 shallow temperatures (down to 900 feet) and bottom profiles along all tracks of the ships.

Through the combined efforts of the British National Institute of Oceanography and the Woods Hole Oceanographic Institution, a countercurrent under the Gulf Stream was charted last year. Eight crossings of the North and Central Atlantic Ocean, with some 140 "deep stations" completed en route, also were made by ships of the two institutions. The data from these cruises will shortly be forwarded to the IGY Data Centers.

Indoor Electronic Train Pulls 10-Ton Load

AUTOMATIC TRACTOR-TRAIN, traveling at 2¼ mph, delivers heavy materials along a "route" of 11 service-point stops. Installed in the stores section of Esso Standard Oil Company's Baton Rouge, La., refinery, the train is electronically controlled by a magnetic wire in the floor and stop-selector control panel on the tractor. Service points send out sensitive electronic signals which stop the train at the proper places. Known as the "Guide-O-Matic," the train can pull up to five trailers, each with a capacity load of 2 tons. Made by the Barrett-Cravens Company, Northbrook, Ill., it took two weeks to install.

World Trade Fair at New York Coliseum

Hundreds of new inventions, industrial developments, and new products were displayed by exhibitors from more than 60 nations during the 2nd Annual U. S. World Trade Fair. Held at the New York Coliseum May 7-17, the Fair contained over 3,000 displays, and featured 35 distinctive national pavilions, among them a representation of a Balinese temple from Indonesia, and a miniature tropical island from Puerto Rico.

Sponsored by the New York City Department of Commerce and Public Events, the U. S. World Trade Fair was organized under the direction of Charles Snitow, its president, and supported by both the New York State and the Federal governments. The entire 9-acre 4-floor area of the Coliseum was covered by exhibits of products such as a Swiss electric platewarmer for table use; a German minicamera, weighing 3¼ ounces, with a built-in exposure meter; a Japanese electrically operated hand-knitting machine; and a new "miracle" fiber, called Rhovyl, from France.

The Fair was officially opened on May 7 by the traditional breaking of the largest loaf of bread ever baked, signifying the relationship of the Fair to world peace and prosperity. At the opening ceremonies, C. D. Dillon, Deputy Under-Secretary of State for Economic Affairs, delivered a message from Pres. Eisenhower. Other special events which occurred during the 11-day exposition included Inter-American Friendship Day, given by the Latin American Chamber of Commerce; the Spanish Government's Fiesta; a Swiss Wine Tasting; and receptions by several other governments. Interpreters were on hand to describe, in several languages, the various products exhibited, in order to help those of the visitors speaking only one language.

Arrangements of ultramodern products were displayed alongside creations of traditional handcrafts—precision tools and hand-woven fabrics, high-fidelity equipment and intricately carved African masks, new coffee makers and ancient herbs. Elaborate assortments of foods, both familiar and exotic—cheeses, wines, chocolates, and packaged delicacies—were shown in great profusion.

Because businessmen from abroad during last year's Trade Fair expressed a desire for more personal contacts with buyers, more days and hours were devoted this year to trade sessions, which were reserved exclusively for the transaction of volume business between buyers and exhibitors.

AEC Foreign and Domestic Reports

AEC's Exhibit in Geneva Commercial Exhibition. A contract for the design and operation of the AEC's exhibit in the 2nd International Exhibition of the Peaceful Uses of Atomic Energy—a commercial exhibition—in Geneva, Switzerland, from September 1-14, 1958, has been awarded to the Atomic Industrial Forum, Inc., New York, N. Y.

The Atomic Industrial Forum, Inc., a nonprofit organization, has agreed at cost and without fee, to design, fabricate, install, operate and dismantle the Atomic Energy Commission's exhibit.

The commercial exhibition will be held in the Palais des Expositions in downtown Geneva at the same time that the United Nations' 2nd International Conference on the Peaceful Uses of Atomic Energy, featuring the official presentation of technical papers and technical exhibits by many nations, is in progress at Geneva's Palais des Nations. The commercial exhibition is a display by industrial manufacturers throughout the world of atomic energy equipment, components, products, and services available on the open markets to those who wish to buy them.

A central display in the downtown Geneva Exhibition will depict the progress made in the United States in developing the peaceful uses of atomic energy and the partnership between United States private enterprise and Government which has made this possible.

The AEC's exhibit will have a secondary theme stressing the power reactor fuel cycle. The exhibit will illustrate exploration for ores, fuel preparation, use of fuel in producing power, and disposal of spent fuel elements. This theme will serve to integrate the exhibits of the individual American companies.

Operation of First Portable Pool Reactor. The initial operation of the *AGN 211* nuclear reactor at the Brussels World's Fair, the first commercial reactor to be airlifted was announced recently. The *AGN 211* was flown by commercial airlines from San Francisco to Brussels where it was assembled and placed into operation in the International Palace of Science. This reactor, loaned to the AEC and National Science Foundation for use as part of the United States exhibit, has attracted great general and scientific interest abroad. It is estimated that some 30 million people will have the opportunity to view the operation of this reactor, the only operating reactor to be exhibited by any nation at the 1958 Brussels World's Fair.

The *AGN 211* is a swimming pool type reactor using enriched uranium fuel. The pool in which the fuel elements are immersed is located in the International Palace of Science; the core can be easily seen within the pool.

Flying Nuclear Reactor. The "flying" nuclear reactor designed and built for the U. S. Air Force at Convair (Fort Worth) Division of General Dynamics Corporation has been transferred to Oak Ridge, Tenn., where it will be suspended from four 300-foot towers for further atomic radiation testing, Convair and Air Force officials disclosed recently.

The portable reactor made 47 experimental flights from Fort Worth aboard a modified but conventionally-powered *B-36* bomber, the *NB-36H*. It was the world's first airborne reactor.

At the Oak Ridge Facility, the reactor will be suspended from the four towers for a joint AEC—Air Force study of radiation patterns. The information will be used in design of compartments to protect crews of nuclear-powered airplanes.

The reactor, a crew compartment, and measuring devices will hang from the boom. The reactor will be attached to a device that will allow it to be rotated. The test rig was designed by the nuclear design group.

During tests in the *NB-36H*, the reactor was operated only after the plane was flying over unpopulated areas. The tests furnished information on radiation patterns and crew protection within the plane.

Nuclear Power Plant at Piqua. A contract has been filed with the Joint Com-

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mittee on Atomic Energy of the Congress in accordance with the requirements of the AEC's 1958 authorization act for research, development, fabrication, and construction of a 12,500 electrical kw nuclear reactor, moderated and cooled by a high boiling point hydrocarbon and fueled by slightly enriched uranium.

The City of Piqua, under a separate agreement with the AEC, would provide the site near its existing steam plant on the Great Miami River and the conventional turbogenerating and relating facilities. Piqua would also operate the entire plant for five years as part of its electric power and industrial steam system and purchase from the AEC the steam produced by the reactor.

Sale of Uranium to Foreign and Domestic Buyers. The U.S. AEC has announced that domestic producers of uranium ores and concentrates may now make private sales of these materials to domestic and foreign buyers for peaceful uses of atomic energy. As in the case of other forms of uranium materials, such as refined salts and metal, all sales will be subject to licensing by the Commission.

As a result of this action by the Commission, United States industry will be able to compete with other countries for the growing foreign and domestic market for nuclear fuel.

Special nuclear materials (U-233, U-235, and plutonium) remain on a government-to-government basis and cannot be sold directly to private users in the United States or abroad. Regulations covering the sales are available from AEC, Washington 25, D.C.

Schedule Conference on Electrical Connections

The 3rd Electronics Industries Association (EIA) Conference on Reliable Electrical Connections, is scheduled for December 3-5, in Dallas, Texas. Open to anyone in the electrical manufacturing or electronic field, the conference will deal with all types of electrical connections including (1) those which are out-of-sight and within (internal) component parts, such as connections inside capacitors, and (2) those which are exposed (external) and parts of an electrical or electronic system. U.S. Government and military authorities from the Air Force, Army, and Navy will be on hand to discuss military specifications and inspection procedures.

All papers to be presented at the conference will be ready for distribution in printed form six weeks in advance. At the conference, authors will give a brief summary of their papers to introduce the topic and then the conference will be thrown open to questions and discussions. There will be no exhibits, no formal luncheons or dinners, and no entertainment because of the importance of the subject.

Papers and case histories, particularly those describing proved solutions to actual connection problems, are sought for presentation at the conference. Those who can contribute case histories or an appropriate paper should write at once to R. G. Roesch, general chairman, 1068 S. Clinton St., Syracuse 4, N. Y. The deadline for papers is August 15, 1958.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Illustrations should be submitted in duplicate, one copy and inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Unified Dimensions Theory

To the Editor:

In reference to L. W. Allen's article entitled "Dimensions for a Unified Theory of Electromechanics," which was published in your February 1958 issue, I would like to submit the following comments:

Mr. Allen states that the need for a fourth dimension in a combined theory of electromagnetics and mechanics has arisen because it has been considered necessary to have a fundamental electric quantity dimensionally independent from mechanical quantities. However, a set of fundamental dimensions is *incomplete* when the number of fundamental dimensions composing it is less than the number required for a dimension system.[1] The application of an incomplete dimension system is very restricted and in some cases can lead to confusing relations.

The number of fundamental dimensions required for a complete dimension system is determined as a difference between the number of dimensions which are present in a set of independent experimental laws of the nature and the number of equations in this set.

Complete dimension systems in mechanics *must have* three; in thermo-dynamics four; and in *electromagnetism four* fundamental dimensions.

Proportionality constants of physics have dimensions. In a logical complete dimension system, the proportionality constants should have *derived dimensions* in order to give the preference to physical quantities rather than to the proportionality constants. An assumption, that the proportionality constant is a pure numeric dimensionless value, will reduce the dimension system to an incomplete one.

The old Absolute Electrostatic and Electromagnetic Dimension Systems were well unified with the mechanical dimension system separately, but they could not be combined together because of the assumption that the absolute dielectric constant and the absolute permeability are dimensionless values equal to unity.

The proposed set $[\sqrt{F}, L, T, k_e = 1]$ is the incomplete dimension system similar to the absolute electrostatic dimension system $[M, L, T, k_e = 1]$ because both systems assume that the absolute dielectric constant is equal to unity. The difference is that instead of the real physical quantity-mass, which can be measured and compared with a standard mass, a fictitious quantity, square root of force is proposed as a fundamental dimension.

An attempt to relate fictitious quantity $[\sqrt{F}]$ to voltage $[V]$ in equation 2 of the article failed because equation 3, from which equation 2 was derived, is a dimensionally *incomplete* physical equation. The classical theory of the electric field presented by Abraham and Becker[2] is based on the absolute electrostatic dimension system $[M, L, T, k_e = 1]$. The equation 3 of the article under discussion

$$F = QE + \frac{1}{2} r^3 \frac{k-1}{k+2} \operatorname{grad} E^2 \qquad (3)$$

is derived on the assumption that the absolute dielectric constant is equal to unity. Therefore, equation 3 is dimensionally incomplete and it is valid only for the absolute electrostatic dimension system. It can be easily checked by inserting the dimensions of the physical quantities into equation 3 and comparing the derived dimension for the two terms on the right-hand side of equation 3.

In the absolute electrostatic dimension system all physical quantities of equation 3 have the following dimensions:[3]

$$|F| = |M|\,|L|\,|T|^{-2}$$

$$|Q| = |M|^{\frac{1}{2}}\,|L|^{\frac{3}{2}}\,|T|^{-1}$$

$$|E| = |M|^{\frac{1}{2}}\,|L|^{-\frac{1}{2}}\,|T|^{-1}$$

$$|r| = |L|$$

$$|k| = |0$$

$$|\text{grad}| = |L|^{-1}$$

Inserting these dimensions into the two terms on the right-hand side of equation 3 the dimensions obtained are:

$$|Q|\,|E| = |M|^{\frac{1}{2}+\frac{1}{2}}\,|L|^{\frac{3}{2}-\frac{1}{2}}\,|T|^{-1-1} = |M|\,|L|\,|T|^{-2} = |F|$$

$$|r|^3\left[\frac{k-1}{k+2}\right]|\text{grad}|\,|E|^2 =$$

$$|L|^3\,|0|\,|L|^{-1}\,|M|^{\frac{1}{2}\times 2}\,|L|^{-\frac{1}{2}\times 2}\,|T|^{-1\times 2} = |M|\,|L|\,|T|^{-2} = |F|$$

The dimensions of equation 3 are correct in the absolute electrostatic system. In the electrotechnical dimension system [F, L, T, Q] all physical quantities of equation 3 have the following dimensions:

$$|F| = |F|$$

$$|Q| = |Q|$$

$$|E| = |F|\,|Q|^{-1}$$

$$|r| = |L|$$

$$|k| = |0|^*$$

$$|\text{grad}| = |L|^{-1}$$

The dimensions of the two terms on the right-hand side of equation 3 are as follows:

$$|Q|\,|E| = |Q|^{1-1}\,|F| = |F|$$

$$|r|^3\left[\frac{k-1}{k+2}\right]|\text{grad}|\,|E|^2 = |L|^3\,|0|\,|L|^{-1}\,|F|^2\,|Q|^{-1\times 2} =$$

$$|F|^3\,|L|^3\,|Q|^{-2} = |F|$$

* Dielectric constant of a substance, k is a pure numeric in any system of units.

The dimension of the last term of equation 3 differs from the force dimension [F] by a dimension of $[F]^{-1}\,[L]^{-3}\,[Q]^2$, which is the dimension of the absolute dielectric constant in the electrotechnical dimension system. In deriving equation 3 the absolute dielectric constant was assumed to be equal to unity and this fact causes dimensional incompleteness of equation 3.

Mr. Allen's statement that the dimension of voltage is the square root of force does not have a valid theoretical basis because it was based on the dimensionally incomplete equation 3, and the proposed fundamental dimension $[\sqrt{F}]$ does not have any physical meaning. It is obviously desirable to define fundamental and derived dimensions in such a way that the least amount of confusion arises and that easy communication of research is possible. The definition of complete dimension systems in electromagnetism requires from this point of view four fundamental dimensions of real physical quantities. The proposed dimension system [$\sqrt{F}$, L, T] is not valid from this point of view.

At this point, I would like to call attention to the dimension system proposed by Prof. P. Kalantaroff in 1929.[2] In spite of its sound physical base and simple symmetrical dimensional expression, this system[2] was not mentioned in the last edition of Eshbach's "Handbook of Engineering Fundamentals." Prof. Kalantaroff introduced the Planck's constant h as the fundamental dimension into mechanics obtaining the [L, T, h] dimensional system. The dimension system for electromagnetics is developed from the mechanical dimensions system not by adding a new fundamental dimension, but by splitting the Planck's constant into two quantities: electric charge [Q] and magnetic flux [ϕ] in accordance with the dimensional equation:

$$[h] = [Q]\,[\phi]$$

The Kalantaroff's dimension system of electromechanics is a complete set of four fundamental dimensions [L, T, Q, ϕ]. The Kalantaroff's dimension system has no fractional dimensions for all physical quantities of electromagnetics and mechanics. I believe that the Kalantaroff's system gives excellent dimensions for a unified theory of electromechanics.

REFERENCES

1. Handbook of Engineering Fundamentals (book), O. W. Eshbach. John Wiley and Sons, Inc, New York, N. Y., 2nd edition, 1952, pp. 3-04, 3-05, 3-07, 3-08, and 3-09.

2. Theorie der Electrizität (book), M. Abraham, R. Becker, B. G. Teubner, Berlin, Germany, 1933, vol. 1, pp. 55-56, 87-88.

3. Lehrbuch der Elektrotechnik (book), G. Oberdorfer. R. Oldenbourg, Berlin, Germany, 1943, vol. 1, pp. 15-32.

Very truly yours,

V. A. KINITSKY (AM '53, M'57)

(Senior electrical engineeer, Ebasco International Corp.)

To the Editor:

In the February 1958 issue, L. W. Allen presented an interesting set of electromechanical units having three, rather than four, dimensional parameters. But it should be noted that Mr. Allen's equation 3 presupposes an arbitrary assignment of dimensions, or lack of dimensions, to the dielectric constant of free space. Thus, Allen's units, like all prior, self-consistent sets of electromechanical units (e.g., see Sarbacher and Edson, "Hyper and Ultra-high-Frequency Engineering," 1943), is derived from four arbitrarily chosen and defined values, one of which, if so desired, may be either the dielectric constant or the permeability of space.

The number of dimensional parameters can be reduced to two, if the other two of the necessary four arbitrary definitions are used to define the dielectric constant and the gravitational constant. One such two-parameter set of units is based on the hypothesis that, in free space, dielectric constant, permeability, gravitational constant, and velocity of light are but different manifestations of a single characteristic of space, which can be represented by a universal space-constant having the dimensions of velocity. This is a plausible hypothesis: why should empty space—mere nothingness—be characterized by four different constants, when one will serve as well? For convenience, we can call the universal space-constant "the velocity of light" and can represent it by the symbol c. Using the space-constant c, and, for free space, omitting gravitational constant, dielectric constant, and permeability, we can write three almost-identical force equations: (1) for the force between two electric charges, (2) for the force between two magnetic poles (magnetic charges), and (3) for the force between two masses (gravitational charges). In each case, the factor c is placed in the numerator, along with the product of the two charges. At this time, only the gravitational force equation contains a minus sign, which signifies that the force between like charges is inward. The algebraic sign in the electric and magnetic force equations will be clarified later.

We can add a fourth force equation: force equals mass times acceleration. By equating the dimensions of each force equation, remembering that c has the dimensions of velocity, and retaining the algebraic signs, we obtain four dimensional equations containing six dimensional units: force (F), length (L), time (T), electric charge (Qe), magnetic charge (Qm), and mass (M). Two of these—e.g., L and T—can be chosen for dimensional parameters, and the dimensions of the other four can be found from the four equations. After the dimensions of these six units have been found, the dimensions

are obvious for other units, such as momentum (Mv), energy (W), gravitational field strength (g), frequency (f), Planck's constant (h), voltage (V), electric field intensity (E), electric displacement (D), magnetic potential (U), magnetic field intensity (H), and magnetic induction (B).

Letting j represent the square root of minus one, the results are summarized in the following condensed dimensional table:

	T^{-1}	T^{-2}	T^{-3}
L^0	$\frac{f}{\pm j}$ (D or B)		
L^1	c	$\frac{g}{\pm j}$ (E or H)	
L^2	$\frac{-M}{\pm jQ}$ (e or m)	$\pm j$ (V or U)	
L^3		$-Mv$	$-F$
L^4		$-h$	$-W$

The exceptional symmetry of length-time units is apparent from the foregoing table. If one unit of time is related to one unit of length by the velocity of light, the magnitude of all units is determined by the arbitrary definition of one unit magnitude—a mere choice of scale. The dimensional parameters L and T are the dimensions of space-time geometry, with the significant addition of the operator j. Every dimension can be considered to include some power of the operator j: the zero power in the dimensions of space-time geometry; the second power in the dimensions of such mechanical quantities as mass and energy; and the first and third powers in the dimensions of electromagnetic quantities of respective polarities.

Very truly yours,

J. W. RALLS (AM '48)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

CONFERENCE ON MANUFACTURING AUTOMATION. 1st and 2nd Conferences, 1956 and 1957. Published by Automation, The Penton Bldg., Cleveland 13, Ohio, 1956 and 1957, 96 and 68 pages, 8¼ by 11¼ inches, paper. $2 each. Papers from two conferences held at Purdue University. Topics covered range from specialized control methods and developments to treatments of both small- and large-scale plant automation, management aspects, and the significance of automation in industry. Some of the papers are reprints of previously published material, but the majority are new.

CONTROL ENGINEERS' HANDBOOK. Edited by J. G. Truxal. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. Various pagings, 6¼ by 9¼ inches bound. $18.50. Provides information on components and techniques for use in the design of feedback control systems. Emphasis is largely on components with physical explanations of how they work, mathematical descriptions of their uses in typical control systems, and techniques for measuring characteristics. Linear transistor circuits, magnetic and thyratron amplifiers, contactors and relays, power supplies, electromechanical actuators, clutches and brakes, hydraulic and pneumatic components, and signal transducers are treated from a feedback control engineering viewpoint.

FEEDBACK THEORY AND ITS APPLICATIONS. By P. H. Hammond. The Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1958. 348 pages, 5¾ by 8¾ inches bound. $7. Presents methods of linear and nonlinear system analysis. The book begins with a discussion of the properties of feedback, particularly with reference to negative feedback and to stability. It continues with applications of the theory to electronic circuits such as the d-c coupled virtual-earth amplifier, to the synthesis of stabilizing networks, and to servomechanisms. Additional chapters are devoted to nonlinear analytical techniques, control systems employing on–off elements, and electronic analogue simulators.

HOCHSPANNUNGS-ISOLIESTOFFE. By A. Amhof. Verlag G. Braun, Karlsruhe, West Germany, 1957. 313 pages, 6 by 8¼ inches bound. DM 34.50. This detailed treatment of insulating materials for high-tension systems is based on information published over the last 10 years. It provides technical data on the constitution and characteristics of a wide variety of solid and liquid materials with a brief mention of the use of gases and high vacuum. An important feature is the extensive classified list of American, British, German, French, and Swiss standards. There is also a fairly comprehensive bibliography.

HYDRO-ELECTRIC ENGINEERING PRACTICE. Edited by J. G. Brown. Blackie and Son, Ltd., Glasgow, Scotland, 1958. 3 volumes, 7 by 10 inches, bound. 19 guineas. An extensive study of modern British and Continental hydro-electric engineering. The 1st volume covers preliminary hydraulic considerations and the over-all design and construction of civil engineering works. The 2nd studies water turbines, generating plants, control and transmission equipment, and power station planning. Economic considerations, operation and management, and maintenance are dealt with in the 3rd and final volume. Fine illustrations, excellent typography, chapter bibliographies, and indexes to each volume add to the reference value of the work.

AN INTRODUCTION TO AUTOMATIC COMPUTERS. By Ned Chapin. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1957. 525 pages, 6¼ by 9¼ inches, bound. $8.75. Intended to convey the computer's functions from a business systems point of view, with its uses and limitations. A discussion of major analysis techniques is included, with reference to applications, programming, and operation. Many specific examples are included for purposes of illustration. Appendixes provide extremely detailed data on automatic computers commercially available, including information on the arithmetic and logic unit, the storage unit, and input–output equipment.

DIE ISOLIERSTOFFE DER ELEKTROTECHNIK. By Wilhelm Oburger. Springer-Verlag, Vienna, Austria, 1957. 542 pages, 6¼ by 10 inches, bound. $26.20. This comprehensive treatise on electrical insulating materials deals first with the mechanical and thermal properties of such materials and with their behavior in an electric field. Separate chapters are devoted to general treatments of gaseous, liquid, and solid materials, and to natural and artificial insulators in various forms. Codes and test methods are discussed, the types and manufacture of insulated windings are described, and an extensive list of references is included.

MANAGEMENT FOR ENGINEERS. By R. C. Heimer. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 455 pages 6¼ by 9¼ inches, bound. $6.75. The fundamentals of business costs are analyzed in relation to their implications for the engineer. Among the aspects discussed are production costs, standards, materials, methods, taxes, insurance, power, equipment, labor, and ethics. An imaginary firm is used to illustrate the principles discussed.

THE MEASUREMENT OF COLOUR. By W. D. Wright. The Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1958. 263 pages, 5¼ by 8¼ inches, bound. $10.75. Describes the principles, methods, and applications of the trichromatic system of color measurement. Areas covered are radiation in the visible spectrum, principles of photometry and colorimetry, colorimeters and spectrophotometers, color spacing and the color atlas, color-mixture data applied to three-color reproduction, and practical applications of colorimetry.

NATIONAL ELECTRONICS CONFERENCE PROCEEDINGS, 1957. Published by the National Electronics Conference, 84 E. Randolph St., Chicago 1, Ill. 1958. 1,066 pages, 6¼ by 9¼ inches, bound. $7.50. A wide variety of topics is covered in the 93 technical papers included in these proceedings: transistor circuits, servomechanism applications, microwaves, radio astronomy, components, computers, radar and radio navigation, instrumentation, magnetic amplifiers, electron tubes, semiconductor devices, and network synthesis.

NUCLEAR RADIATION DETECTION. By W. J. Price. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 382 pages, 6¼ by 9¼ inches, bound. $9. A compilation of basic information on the important nuclear-reaction detectors in use today, such as ionization chambers, the Geiger–Müller, and proportional counters, scintillation detectors, photographic emulsions, and neutron-detection methods. Included with the description of the detectors is sufficient information on applications to enable the reader to select his own detection equipment and to apply it. In addition, there are chapters on the fundamentals of nuclear physics and on electronic systems for use with radiation detectors.

ORAL COMMUNICATION OF TECHNICAL INFORMATION. By R. S. Casey. Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y., 1958. 199 pages, 5¼ by 7½ inches, bound. $4.50. Written to provide a practical guide to effective speaking for technical personnel, the book covers organization of material, composition, delivery of formal and impromptu speeches, and the use of mechanical aids such as recordings and slides. In addition, special sections are devoted to presiding at meetings, presenting science to the layman, and giving technical legal testimony.

THE RADIO AMATEUR'S HANDBOOK. American Radio Relay League, W. Hartford 7, Conn. 35th edition, 1958. 584 pages, 6½ by 9½ inches, paper. $3.50. A new edition of a standard manual which contains information of value both to radio amateurs and engineers. In addition to a considerable amount of basic information, new data has been provided on radio teletype machines and circuits, semiconductors, vhf high-powered amplifiers, and beam antennas. Features include a data chapter on vacuum tubes and a catalog section describing communications equipment.

RADIOGRAPHY IN MODERN INDUSTRY. Published by Eastman Kodak Company, X-ray Division, Rochester 4, N.Y., second edition, 1957. 136 pages, 8¼ by 11¼ inches, bound. $5. A practical guide to the use of radiography in nondestructive testing techniques. Topics discussed include X-ray and gamma-ray sources, factors governing exposure, radiographic screens, scattered radiation, sensitivity and detail visibility, processing, and the characteristics of X-ray films.

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THE ROLE OF SOLID-STATE PHENOMENA IN ELECTRIC CIRCUITS. Proceedings of the Symposium, April 1957, sponsored by the Polytechnic Institute of Brooklyn, Microwave Research Institute; distributed by Interscience Publishers, 250 Fifth Ave., N.Y. 1, N.Y. 339 pages, 6 by 9 inches, bound. $5. A study of fundamental research in the field of solid-state physics and electronics. The papers included deal with such aspects as basic processes and techniques, including the versitron and the solid-state maser; semiconductor properties and techniques; magnetic properties and techniques; and phototechniques. This is the seventh volume of the Microwave Research Institute Symposium series.

TELECOMMUNICATION ECONOMICS. By T. J. Morgan. Macdonald & Co., Ltd., London, England, 1958. 452 pages, 5¾ by 8¾ inches, bound. 50s. Attempts to cover as many aspects as possible of the economic problems to be solved when planning external line plant and internal switching plant for a telephone system. Consideration is given to the layout of multi-exchange systems for rural and urban areas, and to the economic routing of telephone traffic within large and multi-exchange systems and between systems. Various methods to be used when carrying out economic studies are examined.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

INSULATION ENGINEERING FUNDAMENTALS. By G. L. Moses, this book is designed to help the beginner as well as the more experienced insulation man. Contents include chapters on basic insulation concepts, electronic power frequency insulation, high-frequency electronic equipment insulation, testing electrical insulation, and a glossary of insulation words and phrases. The book is illustrated and completely indexed. It is available at $2.75, for the paperbound edition, or $6 for the clothbound reinforced library binding edition, from Lake Publishing Corporation, 718 Western Ave., Lake Forest, Ill.

BOOKS ON NUCLEAR ENGINEERING. Catalogue 678 contains a listing of books available from B. H. Blackwell Ltd., Broad Street, Oxford, England, on nuclear engineering and related subjects. The catalogue is divided into the following categories: nuclear and reactor engineering; radioisotopes, radiation detection, and radiation effects; general and introductory, economics, and reference; selection of official publications and reports; selection of books on atomic and nuclear physics; peaceful uses of atomic energy, proceedings of the international conference in Geneva, August 1955; progress in nuclear energy series; and periodicals. In addition, catalogues of books on technology, science, and mathematics will be sent regularly on request.

ADVANCES IN DOCUMENTATION AND LIBRARY SCIENCE, Vols. I and II. Volume I, "Progress Report in Chemical Literature Retrieval," was edited by G. L. Peakes, Allen Kent, and J. W. Perry, and is based on symposiums of the Division of Chemical Literature, American Chemical Society, held in Minneapolis, Minn., in September 1955 and April 1956. Subjects dealt with include advances in mechanization of patent searching, the engineering approach to chemical literature, and the unit card system in the indexing of internal technical reports. Volume II, "Information Systems in Documentation," was edited by J. H. Shera, Allen Kent, and J. W. Perry, and is based on the symposium on Systems for Information Retrieval held at Western Reserve University, held in Cleveland, Ohio in April 1957. Papers presented at this symposium describe systems ranging from traditional card indexes through punched cards, machine coding, and mechanical sorting to prospective applications of photography, telecommunication, telefacsimile, and computer-like mechanisms. Both volumes are available from Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y. Volume I is $4.75; Volume II is $12.

GOVERNMENT—UNIVERSITY RELATIONSHIPS IN FEDERALLY SPONSORED SCIENTIFIC RESEARCH AND DEVELOPMENT. Prepared by the National Science Foundation, Washington, D. C., this report describes the evolution of Federal sponsorship of research and development at educational institutions and indicates the current nature, trends, and magnitude of this financial support. Problem areas of Government–university relationships, as identified by university scientists and administrators and by Federal agencies, are discussed and recommendations are submitted for the consideration and possible guidance of Federal agencies. The report calls for increased Federal support of basic research at educational institutions and emphasizes the need for continuity of support in the interests of effective conduct of basic research. Copies of the report may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 40¢.

THERMAL PROPERTIES OF 13 METALS. Today's technological developments present many heat transfer problems involving the utilization of the thermal properties of materials. The thermal properties of present concern are thermal conductivity, thermal expansion, specific heat, and density. Thermal diffusivity may be calculated from the known values of thermal conductivity, specific heat, and density. A program conducted by Battelle Memorial Institute, Columbus, Ohio, for the Wright Air Development Center was directed toward the experimental determination of the named thermal properties of 13 metals. Extensive data is supplied for aluminum (2 grades), chromium, copper, Inconel (2 grades), magnesium, molybdenum, Monel K, and steel (4 grades). Compiled by C. F. Lucks and H. W. Deem, this book, Special Technical Publication No. 227, may be obtained from American Society for Testing Materials (ASTM) Headquarters, 1916 Race St., Philadelphia 3, Pa., at $1.25.

PROCEEDINGS OF THE CONGRESS ON ULTRAHIGH-FREQUENCY CIRCUITS AND ANTENNAS, 1957. Published by the Société des Radioélectriciens, the Proceedings contain all the communications presented at the Congress of 1957. The texts are published in English or French, according to the language used by the author. Copies, at 5,000 francs each, may be ordered from Congrès Circuits et Antennes Hyperfréquences, Sté des Radioélectriciens, 10, Avenue Pierre-Larousse, Malakoff (Seine), France. A pamphlet containing the abstracts of the communications, published both in English and French, is also available at 1,000 francs.

UNCONVENTIONAL POWER SOURCES, Parts 1 and 2. A survey, sponsored by the U.S. Air Force, showing means of converting solar, thermal, chemical, and mechanical energies into electricity has resulted in the selection of five "unconventional" power sources which appeared most promising. The two-part report of this survey has been released to industry through the Office of Technical Services (OTS), U. S. Department of Commerce. The study involved the theoretical and practical limitations and capabilities of power generation by means other than rotating machinery, conventional batteries, or radioactivity. The data, drawn from the literature and limited laboratory work, was intended to determine where emphasis should be placed in a possible development program. The most practical of the unconventional sources appeared to be the oscillating electromagnetic generator, thermopile generator, ion-exchange membrane, fuel cell, and photovoltaic battery. These underwent detailed study as described in Part 2 of the report. In the preliminary survey, described in Part 1, data and theory were also compiled on the Workman-Reynolds effect, emission, pyroelectricity, thermomagnetic generators, electrokinetic transducers, electrostatics, piezoelectricity, and magnetostriction. The survey was conducted by A. L. Betts and P. A. McCollum, Oklahoma A & M College, for Wright Air Development Center, U. S. Air Force. The reports, *PB 131411, Part 1*, September 1954, 74 pages, $2, and *PB 131218, Part 2*, September 1955, 75 pages, $2, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C.

INTERNATIONAL LIGHTING VOCABULARY OF THE INTERNATIONAL COMMISSION ON ILLUMINATION, Volume 1 (2nd edition). This new international vocabulary of lighting terms, prepared by the Commission Internationale de l'Eclairage (C.I.E.), is printed in French, English, and German. The vocabulary was created in order to facilitate communication among scientists throughout the world who are working in the field of illumination. The publication contains 550 defined terms, as well as numerous symbols and formulas. Its principal sections cover radiation, photometry, colorimetry, eye and vision, production of light, lamps, auxiliary apparatus, lighting techniques, lighting fittings, and light signals. Volume 2 of the publication will be published in 1959. It will contain the same terms, without definitions, and will be printed in 10 languages: French, English, German, Danish, Dutch, Italian, Polish, Russian, Spanish, and Swedish. The material will be arranged systematically, with 10 alphabetical indexes. The U. S. National Committee of C.I.E. has placed a prepublication order for the 1st volume and is offering it at a reduced price. A limited number of copies are now available at $2.50. It is expected that the price will be raised when the initial supply is exhausted. Orders for the publication with remittances payable to U.S. National Committee, C.I.E., should be sent to T. D. Wakefield, treasurer, U.S. National Committee, C.I.E., Vermilion, Ohio.

TELEVISION IN EDUCATION. This booklet presents a survey of the past, present, and future of television in education. Prepared by the U. S. Office of Education, it is available from the U. S. Government Printing Office, Washington 25, D. C., at 55¢.

LIGHT METALS AND ALLOYS B-7. This compilation of American Society for Testing Materials (ASTM) specifications and methods of test for light metals and alloys has been prepared to make these standards available in convenient form. It supersedes the December 1955 edition, and includes not only those specifications and methods of test which come under the jurisdiction of Committee B-7 on Light Metals and Alloys, but also those for light metal alloy die castings, prepared by Committee B-6 on Die Castings, and those for aluminum wire and cable for electrical purposes, sponsored by Committee B-1 on Wires for Electrical Conductors. Several methods under the jurisdiction of Committee E-1 on Methods of Testing and Committee E-3 on Chemical Analysis of Metals have been added. In addition, specifications for arc-welding electrodes and for brazing filler metal under the jurisdiction of the AWS-ASTM Joint Committee on Filler Metal have been included. Among the general topics covered are ingots; castings; bars, rods, wire, and shapes; forgings; pipes, tubes; sheet, plate; wrought products and filler metal; and electroplating. There are 51 standards of which 36 are new, revised, or have had their status recently changed. Copies of this 320-page book may be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at $3.75.

COLD-CURED PIEZOELECTRIC CERAMICS. A new procedure for preparing cold-cured piezoelectric ceramic bodies suitable for use with commercial sound and vibration-detecting equipment is described in this report released to industry through the Office of Technical Service (OTS), U. S. Department of Commerce. Developed by the U.S. Navy, the inexpensive technique produces discs of commercial-grade barium titanate powder with binders of carnauba wax or liquid sodium silicate. Firing and polarization can be accomplished in one simple operation, thus eliminating elaborate procedures usually involved. Bodies made with both types of binders retained their original piezoelectric properties after three months. Dissipation factors dropped appreciably, especially in discs containing sodium silicate. Experimental discs tested in commercial equipment resulted in clear, undistorted speaker output not audibly different from that obtained from a barium titanate disc fabricated in the conventional manner. The report, *PB 131523*, A. D. Burbage and M. J. Riley, Naval Research Laboratory, February 1958, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D.C. Price 50¢.

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Building upon proven control techniques, Westinghouse has developed *new concepts* to make automatic power system control practical for *any size* utility. This new equipment has many unique features with unusual flexibility and is designed to meet the exact requirements of your system.

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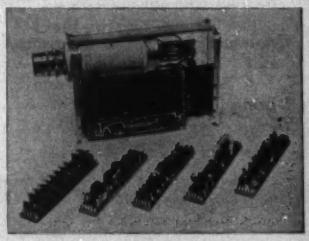
NEW PRODUCTS

Sensistor and Germanium Transistor. Commercial availability of the "Sensistor," a completely new silicon resistor, has been announced. It will allow even further transistorization of both military and commercial circuitry. Its most significant characteristic is that it has a 0.7% per degree C positive temperature coefficient of resistance. This device responds to an increase in temperature with an increase in resistance that rises rapidly along a stable, retractable characteristic curve. Because of its large positive temperature coefficient, the Sensistor is expected to have wide application as a temperature compensating device in miniaturized amplifiers, servos, computer switching circuits, magnetic amplifiers, and power supplies. Also available is a new high-frequency diffused base germanium transistor. In the first commercial application of new diffusion manufacturing techniques, this Texas Instruments advancement enables manufacturers to realize high gain at high frequencies ideal for television i-f stages, radio r-f stages, and vhf oscillators. The same transistor, available in a *JETEC TO-05* outline package, is especially well suited for use in ultrahigh-speed nonsaturated computer applications. For further information contact Texas Instruments Incorporated, P. O. Box 312, Dallas, Texas.

Funelets. Conclusion of the successful development of a line of funnel flange eyelets for printed circuit and electronic applications is announced by the Circon Component Corporation, Santa Barbara Municipal Airport, Goleta, Calif. Used for terminal and feed-through connections on printed circuits the flared flange of these new eyelets provides an excellent fillet of solder between the eyelet and the circuit pattern. No under head flux inclusions in the connection are possible because of the open character of the installed eyelet. The new line will embody 12 different standard sizes to cover the entire range of printed circuit needs. All sizes will be supplied from brass. Those expected to be most popular will also be available from copper. For further information write to the company.

Annunciator without Relays. An annunciator for monitoring complex automatic systems has been developed by the Panalarm Division of Panellit, Inc., producers of annunciators and other industrial information systems. The annunciator uses static-magnetic controls instead of the precision relays used in the company's conventional annunciator. It reports "off-normal" occurrences on an instrument type panel by both visual and audible means. The annunciator controls have no moving parts and provide a high degree of reliability for monitoring critical operations or conditions. Plug-in design of the static-magnetic elements make it possible to change sequences without rewiring, or to expand the annunciator system as required. The static-magnetic annunciator is particularly applicable to industrial systems where interlock or automatic shutdown are involved. Manufactured by Panellit, Inc., 7401 N. Hamlin, Skokie, Ill.

Miniature Television Camera. Development of a fully-transistorized, automatic television camera has been announced by the Dage Television Division, Thompson Products, Inc., Michigan City, Ind. The camera includes all the technical features of broadcast equipment yet weighs approximately 4 pounds. The unit measures 2¾ by 5¾ by 7¾ inches. The miniature camera has been made possible by replacing all tubes with transistors and all wires with printed circuits. To facilitate and speed up maintenance, the camera has been assembled with modular components.



This means that the camera is built with a series of plug-in, printed-wiring strips, each representing a particular function of the camera system. Highly simplified, the new self-contained camera reduces the usual tangle of interconnecting electric lines to only one coaxial cable. Also, since the camera has all the necessary auxiliary equipment built in, it will operate on almost any adjacent power such as home current, 28-volt d-c ship's power, and even a miniature 7½-volt battery, making it truly portable.

Portable Precision Parts Cleaner. Manufacturer's model *1-2BC-2S-S* automatically removes oils, greases, silicone lubricants, rosin flux, and other contamination from small electronic and electromechanical components and assemblies. The precision parts cleaner provides uniformity of cleaning technique and close control over solvent costs; 240 precision instrument bearings are critically cleaned per hour at a solvent cost of 3 mils per bearing. Warm air "dry" time eliminates chilling and condensation during the cleaning cycle. The neutral organic type of solvent is of high specific gravity and excellent stability. It is nonflammable, noncorrosive, nonpolar, and nonionic and will not liberate free chlorides to promote oxidation in hermetically sealed components. It is completely free of all nonvolatile material and leaves no film or residue. The solvent exceeds Federal Specification *PS-6616* covering solvents approved for cleaning of parts and equipment manufactured for the Armed Forces. For further information contact Cobehn, Inc., 126 Passaic Ave., Caldwell, N. J.

(Continued on page 40A)

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1. More People—Four million babies yearly. U. S. population has *doubled* in last 50 years! And our prosperity curve has always followed our population curve.

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FLINT STEEL CORPORATION

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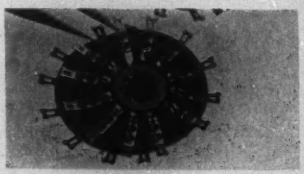
New Products

(Continued from page 20A)

High Chart Speed Oscillograph. A functionally designed two-channel direct writing oscillograph featuring extra high chart speeds of 625 mm and 1,250 mm per second has been announced by Brush Instruments. Whenever signals are changing too rapidly for accurate analysis at conventional chart speeds, this instrument stretches out recording for better chart interpretation and permits precise time correlation between two phenomena on adjacent channels. The wide range of five chart speeds on the Model *RD 2322 10*—5, 25, 125, 625, and 1,250 mm per second—render this instrument ideal for both general-purpose and high chart speed recording. Additional details are available from Brush Instruments, Division of Clevite Corporation, 3405 Perkins Ave., Cleveland 14, Ohio.

Digital Read-and-Write Amplifiers. All-transistor read-and-write amplifiers now provide the system designer with a complete set of building blocks for digital magnetic tape applications. These versatile circuits are easily incorporated into any type of digital system. Voltage levels are compatible with either transistor or vacuum-tube systems of logic. The write amplifier uses logical combinations of two input voltages to provide both return-to-zero (RZ) and non-return-to-zero (NRZ) modes of recording. Pulse response at the two inputs is matched to assure uniform reproduction regardless of tape saturation direction or mode of recording. The basic read circuit is a linear amplifier with a voltage gain of approximately 2,500. Liberal feedback is used to preserve pulse waveform and the frequency pass band is carefully shaped to provide maximum noise rejection. A variety of transitional output circuits is available to supplement the basic read amplifier. For further information contact Decisional Control Associates, Inc., 14141 Stratton Way, Santa Ana, Calif.

Double Eyelet Sections. A double eyelet phenolic section construction is now available for Centralab Series *275* H-type rotary switches. This new construction insures extreme rigidity under the most rugged commercial and military applications. The



double eyelet sections have 19/16-inch mounting centers and are interchangeable with units presently designed for this dimension mounting centers. For additional information contact Centralab, a Division of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

(Continued on page 46A)

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Look around you today. You will see more I-T-E PRIMARY UNIT SUBSTATIONS going into service everywhere—in places where orders are placed after careful evaluation of several different makes. The growing trend toward I-T-E substations reflects the response of shrewd buyers to I-T-E's standing policy of giving more value for no more money. I-T-E engineers work with you in the planning stage . . . custom design the station to meet your particular requirements . . . skillfully arrange I-T-E's quality components into an efficient unit that gives you the maximum value for the minimum investment . . . make deliveries to meet your construction schedules. Make I-T-E your dependable, single source for complete PRIMARY UNIT SUBSTATIONS.

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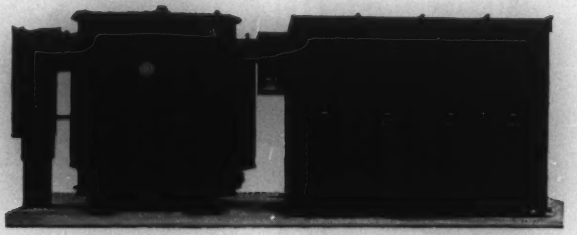

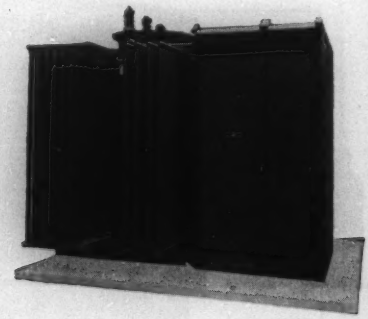

CUSTOM SHEET & PLATE FABRICATION

It takes modern equipment plus craftsmanship and know-how to produce fabrications such as the giant generator housing shown here—illustrative of Kirk & Blum's ability to produce the unusual as well as the conventional types of weldments. In its 170,000 sq. ft. plant, with crane capacity to 25 tons, Kirk & Blum has complete facilities to produce, preassemble and finish a wide variety of carbon steel, stainless, aluminum, monel and other alloys assemblies up to ½" thickness. Fifty years of exceptionally varied experience is your added assurance that the job will be done quickly and economically.

Send prints for prompt quotations or write for detailed literature: The Kirk & Blum Mfg. Co., 8204 Forrer St., Cincinnati 9, Ohio.

ELECTRICAL ENCLOSURES AND HOUSINGS
CONTROL PANELS AND DESKS
BREECHINGS • STACKS • AIR AND GAS DUCTS
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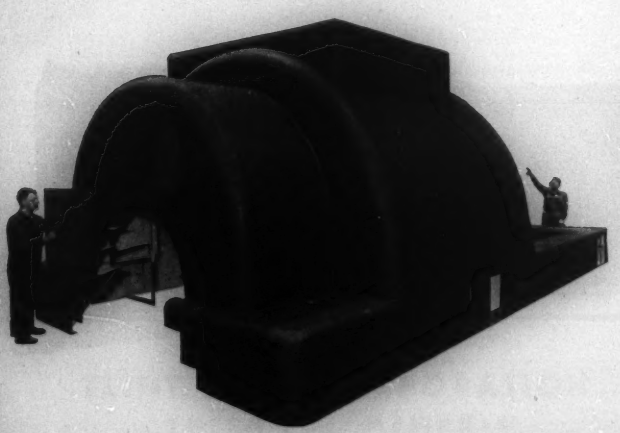
KIRK & BLUM
FABRICATION



New Products

(Continued from page 40A)

Subminiature Lamp. This subminiature lamp recently developed by Chicago Miniature Lamp Works measures ⅛ inch by ¼ inch in length, and has a life expectancy of 60,000 hours or approximately 7 years of continuous burning at 5 volts. Originally designed for integrally lighting aircraft instruments, it is receiving tremendous interest from other instrument designers. Further, more detailed information can be procured from Chicago Miniature Lamp Works, 1500 N. Ogden Ave., Chicago 10, Ill.

Automatic Voltage-Current Control Battery Charger. Development of a new station-type battery charger with automatic voltage-current control, for utilities companies and other operations which use direct current from storage batteries is announced. Automatic features include a magnetic amplifier voltage control and an overriding current control. Write for complete information to Syntron Company, 440 Lexington Ave., Homer City, Pa.

Standoff Insulator. A distribution panel board standoff insulator for systems up to 600 volts is announced by The Glastic Corporation, 4321 Glenridge Rd., Cleveland 21, Ohio. This small, high-strength insulator simplifies bus support on steel framework while offering savings in material cost over bus supports fabricated from composition board, wood, or porcelain. For specification data, prices, and samples, write to the company.

Meter-Lite. A testing device known as Meter-Lite No. 100, combining a voltage tester, a continuity tester, and a handy compact flashlight encased in a guaranteed unbreakable case no larger than a regular pack of cigarettes has been announced by Cessco Industries, 55 Church

St., Albany, N.Y. Of particular interest to all service and maintenance personnel concerned with testing anything electrical, the flashlight is easily used while testing for voltage or continuity.

(Continued on page 50A)

Professional Engineering Directory

Professional Engineering Directory Card 1" or 2" 12 times $160.00

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Consulting Engineers
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Registered Patent Attorney
1234 BROADWAY
(At 31st St.)
New York 1, N.Y.
PHONE
LO. 5-3088

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S. Moskowitz D. D. Grieg N. J. Gottfried
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SLAUGHTER COMPANY
MANUFACTURERS OF TEST EQUIPMENT
HIGH VOLTAGE INSULATION TESTERS
POWER SUPPLIES STROBOSCOPES
SPECIAL TEST EQUIPMENT FOR ENGINEERING AND PRODUCTION
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HIGHLAND ENGINEERING CO.
William R. Spittal & Staff
Design, Development and Manufacture of Transformers, Chokes, Etc. for the Electronics, Industrial and Allied Fields
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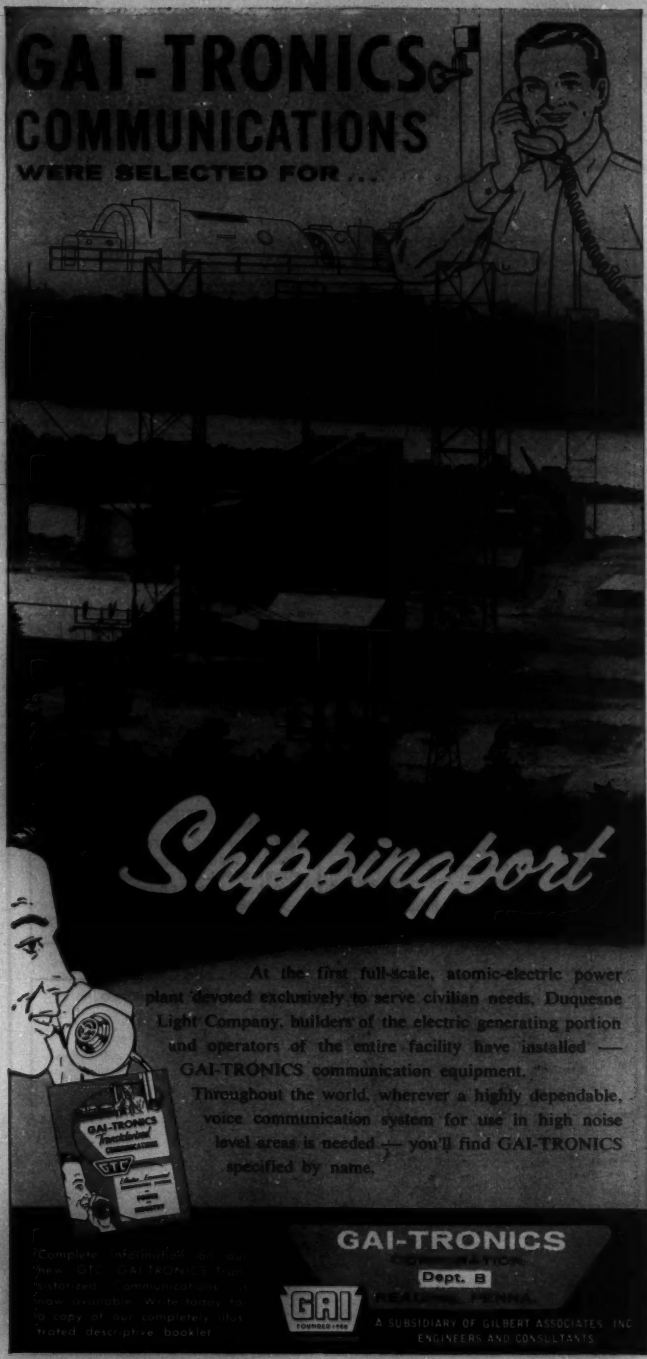
Greeley Colorado

The J. G. WHITE Engineering Corporation
Design—Construction—Reports—Appraisals
80 Broad Street NEW YORK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At the first full-scale, atomic-electric power plant devoted exclusively to serve civilian needs, Duquesne Light Company, builders of the electric generating portion and operators of the entire facility have installed — GAI-TRONICS communication equipment.
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A SUBSIDIARY OF GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

New Products

(Continued from page 46A)

Nonflammable Nontoxic Rust Preventive. This rust preventive for industrial use is now being produced by Lehigh Chemical Company, Chestertown, Md. Effectively packaged in a 16-ounce Aerosol container, Andersol *L-536* rust preventive gives positive protection from rust for all types of metal products and machinery.

Plastigraphic. Pressure-sensitive graphic symbols that simplify panel-board manufacture, and reduce costs from 15% to 25%, are now being used by Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill., on graphic panel-boards designed for automatic control and information systems produced by the firm. The Plastigraphic

symbols are available in a wide range of colors. Made of a pressure-sensitive Mylar plastic, the various lines and symbols can be applied on painted steel panels or Formica–aluminum panels. The flexibility of the material also makes it ideal for making preliminary mockups in the design stages.

Remote Control Industrial TV Camera Head. A practical, economical means for tilting and rotating small industrial type television cameras by remote control is offered in the new Model *RCH-3* camera head. Mounted on a light-duty tripod or other support, the head will handle cameras up to 20 pounds. The control unit can be located at a considerable distance from the head. It incorporates two toggle switches, one controlling rotation, the other tilt. Manufactured by The Houston Fearless Corporation, 11843 W. Olympic Blvd., Los Angeles 64, Calif.

A 7½ Pound Tape Recorder. This tape recorder, no larger than a small clock-radio, and called the Geloso Hi-Tone tape recorder, is the first product of the post-war Italian electronics industry to be marketed in this country. It is manufactured in Milan, Italy, by Societa Per Azioni Geloso, and the recorder is distributed in the United States, Canada, Alaska, Hawaii, Puerto Rico, and Cuba by American Geloso Electronics, Inc., 312 Seventh Ave., New York, N.Y. A portable machine, the Geloso delivers up to two hours of recording on each 3¼-inch reel.

(Continued on page 54A)

Mr. Bull continues:

"As a Commercial and Industrial Representative for the Idaho Power Co., I was asked to redesign the electrical work for the Feed & Supply Center Inc., Twin Falls, Idaho. The installation was handled by Detweiler, an electrical contractor.

"When the job was completed, Fusetron fuses kept blowing on a 15 hp., motor that operates the elevator.

"Larger size Fusetron fuses were tried and the result was almost disastrous.

"When the motor started the whole elevator shaft shook as if it would tear apart. Everyone was afraid that at any second the motor and apparatus would come crashing down the shaft.

"Fortunately, the Fusetron fuses opened and stopped the motor.

"A thorough check revealed that the shaft of the motor was bent in transit.

"If Fusetron fuses had failed to open to protect the motor, there might have been a terrible accident."

You too, can benefit by the 10 point protection of Fusetron fuses.

Fusetron dual-element fuses offer the safest, most complete electrical protection possible. With rare exceptions on commercial and industrial installations — ordinary fuses and circuit breakers protect only against short-circuits — but Fusetron dual-element fuses provide 10 point protection.

Why Risk Losses! One burned out motor . . . one needless shutdown . . . one destroyed switch or panel . . . one burned out solenoid . . . may cost you far more than replacing every ordinary fuse with Fusetron dual-element fuses.

BUSS Hi-Cap Fuses—High Interrupting Capacity above 600 and up to 5000 amperes

BUSS Hi-Cap fuses offer unlimited interrupting capacity for circuits of 600 volts or less. Their high speed operation on heavy shorts limits current to safe values. This minimizes damage to equipment and cuts down dangerous stresses on transformers.

These fuses can be coordinated with Fusetron fuses to isolate fault to circuit of origin.

BUSS Limitron Fuses — Limits Fault Current to Very Low Values

BUSS Limitron fuses have extremely fast opening characteristics to prevent heavy short-circuit currents from building up under fault conditions.

For more information write for —

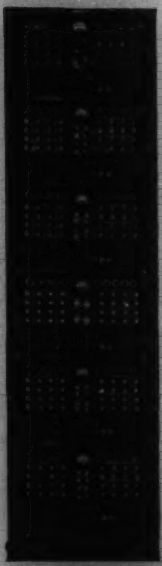
Bulletin FIS *on Fusetron dual-element fuses.*

Bulletin HCS *on BUSS Hi-Cap fuses.*

Bulletin HLS *on BUSS Limitron fuses.*

Bussmann Mfg. Div.
McGraw-Edison Co.
University at Jefferson,
St. Louis 7, Mo.

Play Safe! install FUSETRON dual-element FUSES and BUSS Hi-Cap FUSES throughout entire Electrical System!



MINIATURIZED CARRIER TELEPHONE SYSTEMS FOR RADIO AND 4-WIRE CABLE

FOUR OR 24 CHANNELS

Two miniaturized voice-multiplex systems providing four or 24 voice channels over radio or 4-wire cable are available. They have many advantages over earlier designs: high performance, small size, light weight, low cost, circuit simplicity, low power requirements, small number of tubes of a single type only, low operating cost, low maintenance and high reliability.

These systems provide a voice-channel flat within 1 db from 300 to 3500 cycles, for each 4 kc of bandwidth occupied. Each channel is equipped with hybrid, signalling, and dialling circuits for all the standard 2-wire and 4-wire loop options.

The basic unit provides an order-wire and 4 carrier-derived channels. These units can be stacked in groups of 2, 3, 4 or 5 by means of a group modem to provide 9, 14, 19 or 24 channels. Full flexibility is provided for dropping and inserting channel groups at repeater and terminal points. Moderate lengths of 4-wire cable or open-wire line may be inserted between the multiplex equipment and the radio terminals.

24-channel carrier-telephone terminal complete with hybrids, ringing and dialling circuits, and test facilities. Dimensions are 58" high, 16" wide and 8" deep. Power input 250 watts. Weight 326 lbs.

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CABLES RADENPRO MONTREAL

Review of Input and Output Equipment Used in Computing Systems

(March 1953)

The Joint AIEE-IRE-ACM Computer Conference took place on December 10-12, 1952, in New York, N. Y., to discuss the characteristics and performance of input-output equipment as it applies to large-scale electronic digital computers. The conference was held under the direction of the Joint Committee appointed by the Committee on Computing Devices of the American Institute of Electrical Engineers, the Electronic Computers Committee of the Institute of Radio Engineers, and the Council of the Association for Computing Machinery.

Input-output equipment presents an ever-changing and expanding problem and encompasses a very broad field of devices. This conference stressed those devices which have been brought to the point of working equipment by the various computing groups in an attempt to acquaint a large body of engineers with the present status of the art. The 142 printed pages contain 27 pages and discussions, representing a fairly complete documentation of the input-output art as it existed at the time of publication.

Publication S-53 is available at the price of $4.00 to members and nonmembers. Send orders to Order Department.
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

33 West 39th Street, New York 18, N. Y.

New Products

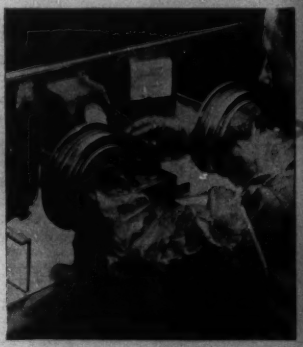
(Continued from page 50A)

Slide Rule Equipped Watch. This watch with a built-in circular slide rule is now available. Designated The Chronomat, this combination chronograph and slide rule can be utilized in an infinite number of ways. The wrist instrument performs multiplication, division, ratios, exchange, conversion, interest, percentages, etc. For further information contact Wakmann Watch Co., Inc., 15 West 47th St., New York 36, N. Y.

Molded Battery Holders. A line of molded plastic battery holders for use by designers and manufacturers of portable radios, phonographs, toys, electronic equipment, and other battery-powered products has been announced. This new battery holder is in the form of a tube and has a threaded end cap so that individual flashlight cells are loaded in a manner similar to a flashlight. For more details, write: Department 284, Mayfair Molded Products Corp., 3700 North Rose St., Schiller Park, Ill.

Smoke Density Transmitter. Smoke density measurements are electrically transmitted to remote indicators and recorders by the Bailey Bolometer transmitter, described and illustrated in the 4-page, Product Specification *E66-1*. Details of radiant energy detection principle of operation are provided along with installation drawings and wiring diagrams. Available on request from manufacturer, Bailey Meter Company, 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Transparent Protective Dry Box. A transparent plastic dry box with entry ports to provide a dust-free draft-free isolated work space with the greatest possible accessibility has been developed by Air-Shields, Inc., Hatboro, Pa. Made of sturdy ¼ inch clear acrylic plastic, the hood is gaining wide use for assembling semiconductors or testing delicate precision



Courtesy Boston Sunday Herald

instruments. Inert gases can be introduced or slight vacuums created when properly mounted. For more information about standard or custom isolation hoods write to S. H. Gilbert, Jr., Air-Shields, Inc., Hatboro, Pa., and ask for bulletin No. *E2*.

The Hughes HA7500 Series

silicon pnp transistors

Ideal for:

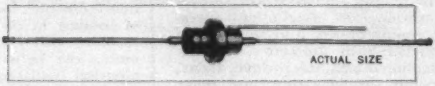
Differential Amplifiers. *Because significantly, the spread for any characteristic of a given type is small, matching becomes easy with this kind of uniformity.*

Low Level Choppers. *Because switching characteristics are excellent, saturation resistances are low; emitter and collector reverse currents are low; emitter to base reverse voltages are high.*

D.C. Amplifiers. *Because variation of characteristics within a type is small, these variations are also little affected by temperature.*

Audio Oscillators, Multivibrators, Flip-Flops. *Because, once again, uniformity becomes significant, as well as the unusual stability of each type, replacement can be accomplished without loss of effectiveness.*

Servo Circuitry, Medium Power Amplification, Phase Detection, Voltage Regulation, Power Control. *Because this series has versatility, both low and high level operation become practical.*



These multi-use transistors have the advantages inherent to all silicon devices plus the typical Hughes advantages of ruggedness and reliability. They have a unique coaxial configuration, developed at Hughes to permit the maximum flow of heat from the crystal through the package while providing an extremely sturdy internal structure. Significantly, this configuration is ideal for machine insertion on printed boards. Dimensions: body length, .396 inch; body diameter, .343 inch.

For details of the various types, please write: Hughes Products, Semiconductor Division, International Airport Station, Los Angeles 45, California.

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

HUGHES SEMICONDUCTORS

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"Private Eye" for the Air Force—at the top of the world!

STRETCHING 3,000 miles across the Arctic is the DEW Line. . . a network of powerful radar stations . . . dedicated to keeping a 24-hour "tail" on polar skies.

This sleepless "private eye" is *operated* and *maintained* by technical personnel of Federal Electric Corporation, one of the fastest-growing ITT associates. Federal Electric also operates Alaska's 3,000-mile "White Alice" communications network, serving the military, the public, and the DEW Line.

Engineers of FEC also are engaged in challenging opportunities all over the world . . . in installation, operation, maintenance, and supervision of custom-built projects . . . for air navigational aids, microwave, radar, telephony, broadcasting, and other types of electronic communications.

In addition to the educational value of domestic and foreign travel, they receive top basic compensation —plus substantial special allowances. And all the while they are building a solid future with ITT's global team.

For the interesting story of FEC engineers and field engineers and their unusual around-the-world assignments, write to ITT Technical Placement Office, 67 Broad Street, New York 4, New York.

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INDUSTRIAL NOTES

European Branch Opened. Burndy Corporation, Norwalk, Conn., a manufacturer of electrical connectors, has opened a branch in western Europe, with headquarters in Antwerp, Belgium. The new branch will be managed by Augustin Bouckaert, a Belgian, who will be responsible to Sidney Wolberg, Burndy vice-president, overseas operations. The branch will furnish electrical connectors, installation tooling, and related products to European electrical and electronic equipment manufacturers, power plants, and other installations.

Continuous Steam-Turbine Blading-Test Program. A continuous test program to obtain more performance data on current blade designs is being conducted in a modern experimental turbine laboratory at Allis-Chalmers West Allis Works. Included in the laboratory, which is also being used in conjunction with other test facilities and with theoretical analysis in the development of new blade designs, is an experimental turbine with its dynamometer equipment. The laboratory's experimental turbine was built to accommodate reaction and impulse blading as well as governing stages and is used for single or multistage tests. For further information contact Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis.

Fiberglas Armature Band. A new procedure for casting Fiberglas bands on armatures of industrial motors that will cut costs in half according to the manufacturer, has recently been introduced. The bandings are actually cast on the armature at the motor manufacturers' own plant using a package method which eliminates time-consuming work when short lengths of banding in 50- to 200-foot rolls are supplied. Full information on the new process can be secured from Pittsburgh Electrical Insulating Co., Inc., 3000 Bigelow Blvd., Pittsburgh, Pa.

Kine-Lab. John Sanabria, associated for many years with the television industry, announces his acquisition of Kine-Lab, Inc., 3250 Kenilworth Ave., Berwyn, Ill. The company will continue to manufacture all types of gun mounts sold to television tube manufacturers.

Name Change. Taurus Corporation is the new name of the Lambertville, N. J. firm formerly known as Metron Corporation, manufacturers of mechanical components and assemblies for the electronics industry. The company's product lines include Teflon insulated terminals and static punched card sensors. Management, sales organization, and product lines remain unchanged. Taurus Corporation, 8 Coryell St., Lambertville, N. J.

Haloid Xerox Inc. The new corporate name of a 52-year-old Rochester firm, formerly The Haloid Company, was approved by shareholders at the annual meeting. The addition of Xerox to the name of the company, once wholly in the photographic-photocopy business, was made in recognition of the recent rapid growth of the xerographic phase of its business. The manufacture of Xerox products for xerography, a completely dry, high-speed copying process was pioneered and developed by Haloid.

Sunlight to Electricity. A practical system of converting sunlight into electric power for the commercial tasks of operating telephone systems, telegraph networks, radios, and other communication and signal devices has been developed by the Hoffman Electronics Corporation's Semiconductor Division, 930 Pitner Ave., Evanston, Ill. The basic component of the commercial solar system is a modular unit, a 12- by 20-inch aluminum panel containing 144 wafer-thin, circular silicon solar cells which instantaneously convert sunlight directly into electric energy. This energy is either fed into storage batteries or used directly.

Conolon 506. A lightweight, strong, heat resistant, and highly formable resin-impregnated Fiberglas is being used to solve a critical missile temperature control problem at Electrofilm, Inc., a North Hollywood, Calif., corporation which manufactures solid film lubricants and temperature control equipment for the aircraft and missile industry. This material, Conolon *506*, is manufactured by Narmco Resins & Coatings Co., 600 Victoria St., Costa Mesa, Calif.

Peek into the Future. A special demonstration was set up by the Computer Division of the Bendix Aviation Corporation, 5630 Arbour Vitae St., Los Angeles, Calif., indicating that computer equipment now available could handle income tax returns on a mass-production basis. The special demonstration, conducted for newsmen, utilized the Bendix *G-15* digital electronic computer.

Meter-Relays. Electrical characteristics are being automatically tested four times faster than formerly by two giant machines recently installed on its production lines by Tung-Sol Electric, Inc., Washington, N.J. Built around versatile instruments called meter-relays, the machines also improve product quality by eliminating human error and by checking product characteristics more thoroughly than human beings can. Operators are needed only to load and unload the machines. Sixty meter-relays, furnished by Assembly Products, Inc., Wilson Mills Rd., Chesterland 33, Ohio, are incorporated in each machine. Each meter-relay is assigned a different task to indicate and control all conditions of all circuits at all times. Besides testing tube characteristics, the meter-relays also monitor all voltages used, and will automatically shut the conveyor down if any improper test conditions develop.

(Continued on page 60A)

New Roeclamp* with Roeplastic® Cable Costs 60% Less than Self-Supporting Cables, Minimizes Tree Problems, Installs with Ease, Looks Better!

New ROECLAMP with ROEPLASTIC Cable is the perfect answer in areas where trees are a problem, where appearance is an important factor, or in areas where the most compact, economical and easily serviced system is desired. That means *just about everywhere!*

Roebling ROEPLASTIC Cable with the remarkable new ROECLAMP, is designed for 5kv use (2400/4160Y and 4800 v delta systems) and 8kv use (4800/8320Y and 7200 v delta systems). Phase identification is positive at a glance, since cables are maintained in the same relative position along their entire length. Phases may be added or removed, and the system may be reinforced *without removing* ROECLAMPS from messenger! *Conductors may be replaced without tools* (except for splices and taps).

Low impedance results in better voltage regulation—and the heat-dissipating properties of the Roebling system mean higher current-carrying capacity. Lightning protection and protection from falling tree limbs are provided by the strong copperweld messenger, which runs the length of the system. Aluminum conductors come in 17 standard sizes and strand constructions to cover a broad range of applications. They are specially made with a greater number of finer strands to give extra flexibility. Standard insulation is extruded ROEPLASTIC P-11R7, although other types of extruded insulations are available, depending upon proposed usage.

The Roebling Aerial Spaced Cable featuring ROECLAMP costs less, installs fast, gives optimum service and requires minimum maintenance. You can't afford not to investigate it! Your Roebling representative can give you a demonstration of the revolutionary new ROECLAMP—and will give you more facts. Call him—or write Electrical Wire Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey.

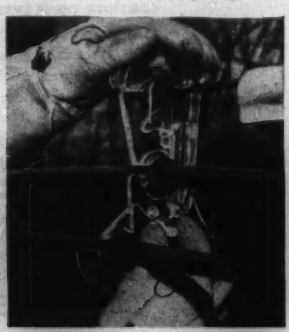
ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

* Patent pending

One motion and ROECLAMP is on messenger and ready to receive conductors. Phase changes and repairs do not necessitate removal of clamp. ROECLAMP comes complete with grommets to fit messenger and conductors you order . . .

Note how easily conductors drop into place. Installation is measured in seconds, even with "boxing" gloves on. ROECLAMP is Plexiglas†, tests to over 1000-lb. breaking strength, offers outstanding weather resistance, best possible electrical properties . . .



35 ROECLAMPS are required every 1000 ft. Installation is completed by hand-tightening of nut. Not even a screw driver is required!

† Reg. T. M.—Rohm & Haas Co.

IMPORTANT NOTICE TO PHYSICISTS AND ELECTRONIC ENGINEERS:

INFRA-RED OPTICS
RADAR SYSTEMS ANALYSIS
ELECTRONIC SUPPORT EQUIPMENT DESIGNERS
MISSILE GUIDANCE SYSTEMS
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SEVERAL UNUSUAL CAREER OPPORTUNITIES:

We have a high priority need for qualified men experienced in any of these fields. Requires Bachelor's Degree in electrical engineering or physics plus 3-6 years' experience. Or an advanced degree plus 2-5 years' experience in design and analysis of communication, detection or control systems.

CONTINUED EXPANSION IN ELECTRONICS & AVIONICS:

Emerson Electric has completed a record-setting year and the pace is not slackening at all! Already a leading manufacturer of missiles and electronic equipment, Emerson has a firmly outlined program for the future. We anticipate increased volume and diversity in 1958, and doubling these figures over the next few years. Therefore, a new, broader organizational structure has created these excellent career openings with complex challenges.

CURRENT PROJECTS AT EMERSON ELECTRIC:

B-58 fire control system, mortar locators, radar components and assemblies, servomechanisms, missiles and rockets, ground support equipment, microwave antennas, F-101 Voodoo structures, plus a host of other electronic devices for the supersonic era. We emphasize research, design and development, with a healthy balance in production.

CONSIDER THESE EMERSON BENEFITS:

- Excellent salary
- Outstanding advancement opportunities
- Advanced education program
- Moving expenses fully paid
- Plus other top-level benefits

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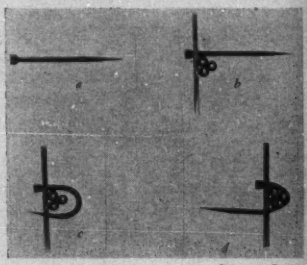
Electronics and Avionics Division
EMERSON ELECTRIC
8100 W. Florissant Ave. • St. Louis 21, Mo.

Industrial Notes

(Continued from page 56A)

Safety Brake Seat on Dynamotive. A safety feature, new safety brake seat, is being built into Automatic Transportation Company's gas powered, electric driven Dynamotive lift truck as an extra. A hinged seat replaces the conventional hand operated lever as the media to apply the parking brake. The seat is spring retained in a normally open braking position at all times that the seat is unoccupied. Thus, the chance of operator neglect in setting the parking brake when leaving the vehicle is eliminated. The company is located at 149 West 87th St., Chicago 20, Ill.

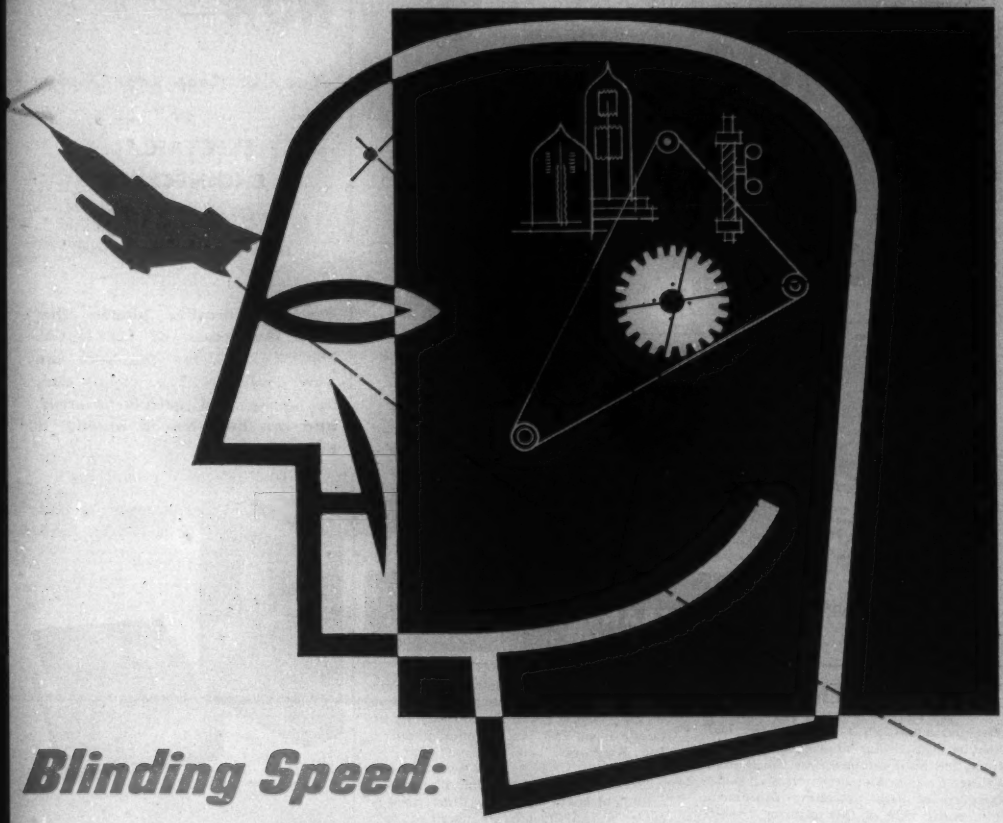
"Mouse Tails". The mouse tails, a recent development at Boeing Airplane Company, Seattle 24, Wash., secure wire bundles to the chassis in the compact electronic packages used in the Boeing *IM-99* Bomarc interceptor missile. The mouse tails are made of a tough rubber compound. They are about an inch and a half long, tapered at one end and knobbed



Courtesy Boeing

at the other. They are installed easily by passing the tapered end through a hole in the chassis, looping the shank over the wire bundle and reinserting the tapered end through an adjacent hole. The button acts as a stop so that the rubber can be cinched up tight. When tension is relieved, expansion of the rubber holds the mouse tail firmly in place. Boeing has applied for a patent on this device.

Humphrey Products Division. Humphrey, Inc., manufacturer of gyros, accelerometers, potentiometers, and other electromechanical instruments, announces the establishment of Humphrey Products Division. The company currently is engaged in an expansion program, and the new division has been set up to facilitate participation in the industrial controls and apparatus field. The principal function of this division will be to accelerate new product development and expand sales operations on products already established. One of the first products of the new division is the Servotran, a mechanical variable speed drive. A sales office has been established for Humphrey Products Division at 3794 Rosecrans St., San Diego 10, Calif.



Blinding Speed:

Speed so great that existing control systems were incapable of directing its flight path . . . so great that newer, more compact, more accurate, virtually automatic control systems were developed to guide the B-58, America's first and only bomber capable of sustained supersonic flight.

Today, this is an outstanding fact of the B-58 . . . sustained supersonic flight, rivaled only by its *growth potential*. This means that tomorrow, it will go even further.

Growth potential in the airplane results from growth potential for the individual engineer. This, and the strong challenge to his creative ability, are integral parts of the new concept in engineering organization at Convair-Fort Worth that has produced such a world challenging weapon.

If your ambitions call for a position that provides such growth potential for you, send a confidential resume of your training and experience for consideration by engineers in the area most suited to your qualifications. For personalized handling, address your inquiry to Box 748L.

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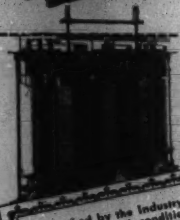

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TRADE LITERATURE

Engineersmanship. This very "learned" booklet, containing appropriate illustrations, has been published by the Benson-Lehner Corporation, designers and manufacturers of data processing equipment. The entire title of this amusing booklet is "On Being an Egghead; or engineersmanship for the shell of it." For a gratis copy write to Benson-Lehner Corporation, c/o Dept. EE, 11930 Olympic Blvd., Los Angeles 64, Calif.

More Than Just Steel. This motion picture tells the story of special-purpose sheet steels, from electrical steel and enameling iron in the early years of the century to special zinc-coated and aluminum-coated steels of today. The film also covers standard and special stainless steels, their development and interesting uses. It runs 30 minutes, is in 16-mm color, and has sound. Write Product Information Service, Armco Steel Corporation, 1553 Curtis St., Middletown, Ohio, or any local distribution office of Modern Talking Pictures, Inc.

Wide-Range Uses of Tenite. A 36-page book that explains how Tenite polyethylene resins can be used to make a wide variety of functional and attractive plastic products has been published by Eastman Chemical Products, Inc., 260 Madison Ave., New York 16, N. Y. Numerous illustrations show the versatility of this plastic and its wide range of applications in housewares, toys, appliances, packaging, paper coating, insulation, and pipe. Copies of "Tenite Polyethylene" may be obtained from Eastman Chemical Products, Inc., Kingsport, Tenn.

Latch Relay Bulletin. A line of mechanically held latched-in relays which need no extra vertical height is described in a bulletin available from the Clark Controller Company, 1146 E. 152nd St., Cleveland 10, Ohio. Bulletin *7305-PML* describes the new Clark Type *PML* latch relay, which lines up with the standard Clark Type *PM* relays with no increase in height, so that standard and latch relays can be located where desired on a panel without waste of space.

Six Basic Business Problems. Bulletin *GEA-6459*, 16 pages, cites major benefits offered to electric utilities using factory-built substations. The publication includes excerpts of reports on factory-built substations and the advertisements placer by General Electric as a result of them. General Electric Company, Schenectady 5, N. Y.

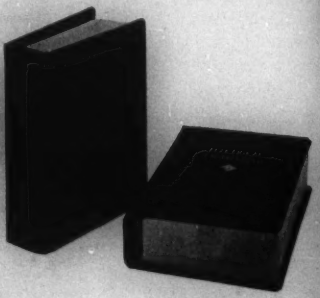
Hermetic Seals and Terminals. A new concept in engineering, quality, and service now available to users of hermetic seals and terminals is described in a recently published brochure offered by Glass-Tite Industries, Inc. Copies of the brochure are available from Glass-Tite Industries, Inc., 88 Spectacle St., Cranston 10, R. I.

(Continued on page 70A)

NOW—

You Can Keep Your Copies of ELECTRICAL ENGINEERING in Orderly Fashion and Good Condition

Practical attractive binders that hold the issues of ELECTRICAL ENGINEERING for one year are now available. Your copies may be easily and quickly inserted, and can be removed readily, if necessary.



Binders have stiff covers of heavy quality dark blue imitation leather, round corners, and are embossed on the cover and backbone with the title, the Institute's emblem, and the words—Jan.-June; July-Dec.

The binders come in sets of two, and at a cost of $4.00 per set (no discounts allowed), with postage prepaid, may be obtained from

Order Department

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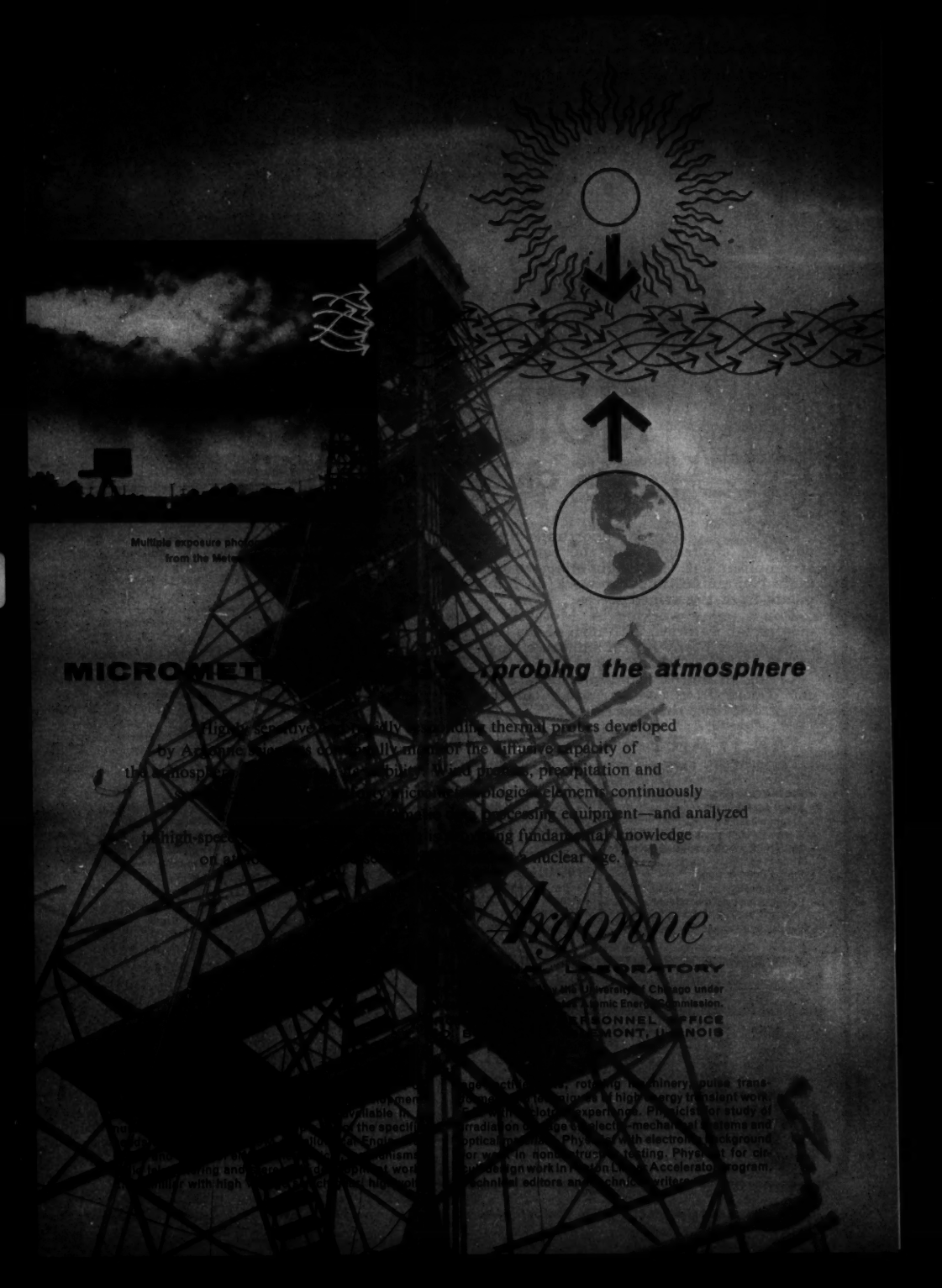
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- Radar transmitters and receivers
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- Antenna design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstron, traveling wave tube and backward wave oscillator
- Display and storage devices

CIVILIAN
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2-WAY RADIO COMMUNICATIONS
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Trade Literature

(*Continued from page 64A*)

"How to Judge a Light Bulb". This booklet was recently issued by the Westinghouse Lamp Division. The pamphlet contains numerous facts about light bulb life, light output, and cost of light. The booklet contains a section on the technical aspects of light bulbs written in easy-to-understand language. Write to Westinghouse Electric Corporation, Lamp Division, Public Relations Department, Bloomfield, N.J.

Beryllium and Industrial Safety. A 12-page booklet on the industrial hygiene aspects of beryllium metal, oxide, alloys, and other beryllium products has been issued by The Beryllium Corporation, P. O. Box 1462, Reading, Pa. Entitled "Plain Talk on Beryllium," the booklet faces squarely the fact that during their extraction and fabrication, some forms and compounds of beryllium, when improperly handled, constitute a health hazard. This hazard need not be viewed with alarm, according to this booklet, if full advantage is taken of industrial experience already gained in the use of beryllium, and indicated safety and hygiene measures are followed.

Epoxy Compounds Brochure. "Epoxy resins—applications and advantages" is the title of an illustrated eight-page brochure recently issued by the Marblette Corporation. The brochure is a comprehensive summary of the uses of epoxy compounds in various industries: metal-forming, plastics-forming, foundry practice, building and maintenance, chemicals processing, electronics and electrical manufacturing, appliance manufacture, automotive and aircraft manufacture, and many others. Copies of the brochure may be requested from Max Hilrich, research director, Marblette Corp., 37-31 Thirtieth St., Long Island City 1, N. Y.

Tape Demagnetizer Bulletin. A large magnetic tape demagnitizer has been introduced by Librascope, Inc., as the latest in its line of "Noiserasers." This Model *N-2* is designed for use in video broadcasting, music and motion picture recording, military telemetering, and commercial data recording. Model *N-2* operates on 110/220 volt 3-wire, single phase, 60 cps, and draws approximately 25 amperes. Bulletin *N-2* is available from the Commercial Division, Librascope, Inc., subsidiary of General Precision Equipment Corp., 40 East Verdugo Ave., Burbank, Calif.

Fork Truck Folder. A 4-page folder, illustrating and describing its Model *F-30T4*, a 4,000 pound capacity, electric powered fork truck, has been published recently. Free copies which contain illustrations showing the truck in action, plus photos of its major components may be obtained from The Elwell-Parker Electric Company, 4205 St. Clair Ave., Cleveland 3, Ohio.

(*Continued on page 72A*)

A 2-WEEK, ALL EXPENSES PAID TOUR FOR TWO

to the Brussels World's Fair

(VIA SABENA BELGIAN WORLD AIRLINES)

AWAITS THE WINNER OF THE "JOBS FOR TOMORROW" CONTEST

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MANUFACTURERS OF MICROSCOPIC GLASS BEADS

7

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2nd PRIZE—Admiral Portable Color Television Set

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Each winner will also receive an award certificate.

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FOR A NEW USE OF MICROBEADS MAY BE A WINNER — SEND FOR CONTEST KIT TODAY!

MICROBEADS . . . A BASIC NEW MATERIAL WITH UNLIMITED POSSIBILITIES—Microbeads are manufactured in sizes ranging from 1 micron to over 1000 microns. The specific gravity range of Microbeads is from 2.4 to 4.6. Refractive index ranges from 1.51 to 1.93.

The primary market for Microbeads is in the field of reflectorization—signs, pavement markings, etc. They have gained wide usage in traffic control products and in the medium of outdoor advertising. We feel, however, that these uses are only the beginning . . . a small portion of the overall role Microbeads is destined to play throughout industry. This thinking is prompted by the many men of vision who have approached us with imaginative ideas for new uses of this product. Some are practical . . . some are not. However, an amazing percentage of these ideas have proven themselves to be both practical in use and feasible from a cost standpoint.

The material contained in the contest kit describes a number of these suggested new uses. Perhaps one of them will spark an idea within yourself . . . and you'll find yourself winging your way across the Atlantic . . . bound for an unforgettable two weeks at the FAIR.

Contest Kit contains samples of Microbeads, general information, fact sheet, official rules, official entry form . . . everything you need to help you win.

Those ideas win which, in the opinion of the judges, will create the most jobs in the next five year period and which most successfully combine originality, feasibility and practicality. The idea itself is all-important; not the depth of development. Serving on the panel of judges are: Dr. R. P. Dinsmore, Vice President Research and Development, Goodyear Tire and Rubber Co., Akron, Ohio; Dr. H. W. Welch, Jr., Director Research and Development, Military Electronics Division, Motorola, Inc., Phoenix, Arizona; Mr. John J. Hanlon, Technical Director, Mohasco Industries, Inc., Amsterdam, New York.

MAIL THIS COUPON TODAY!

CONTEST CLOSES AUGUST 15, 1958

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Gentlemen:

Please send Official Entry Kit for your "JOBS FOR TOMORROW" CONTEST to:

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Organization .....

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SERVO ENGINEERS

Requires B.S.,M.E. or E.E. with 3 to 5 years' experience in dynamic analysis and synthesis of servo systems using analog computers as an aid. Prefer direct experience with hydraulic and pneumatic systems. Will work on analytical group assignments relating to dynamic systems' analysis and synthesis on high-pressure electro-hydraulic devices, high-pressure pneumatic systems, jet engine fuel systems, etc.

CRYOGENICS ENGINEER

Senior Project Engineer is required to organize and assume charge of a small group engaged in the development of airborne equipment for the generation and use of high-pressure gas from cryogenic liquids, which will be used for control and actuation of various devices on aircraft and missiles.

Responsibility will include proposal and cost-estimate preparation, project planning, engineering coordination with customers, supervision of design and analytic work, development of low-temperature components, planning for laboratory test facilities, production support activity, and all else necessary to carry a project from the preliminary concept through full qualification testing of flightworthy hardware.

Five to ten years' experience is required in this or related fields, with a good background also in the general area of thermodynamics and general physics, as well as in design and development work.

●

Modern plant located in suburban area offers ideal living conditions and excellent school facilities. Expanding company offers excellent opportunity for advancement.

Send resume detailing educational background and experience to:

Personnel Department

CHANDLER-EVANS DIVISION

PRATT & WHITNEY CO., INC.

West Hartford, Conn.

Qualified applicants will be invited to West Hartford plant for personal interview concerning these positions.

Kingdom of Iraq

Ministry of Development and Development Board

The Development Board engages for the new power system to be put into operation during the last quarter of 1958 and comprising two steam power plants of 60,000 kW, and 80,000 kW, and a 132 kV High Voltage Transmission system:

- *power station and transmission system superintendents*
- *operating and control engineers for power stations and transmission system*
- *maintenance engineers for power stations and transmission system*
- *shift operating engineers for power stations*
- *mechanical and electrical foremen (engineers) for the power stations*
- *line and substation maintenance foremen (engineers)*
- *carrier current and instrument technicians for transmission system equipment.*

Qualifications required: Only applications from persons with high qualifications and professional standing and with experience in similar jobs will be considered. Good knowledge of English preferable.

Conditions proposed:

- good remuneration
- housing and furniture allowances
- free passages for agent and family
- one month foreign leave per year
- duration of contract: about two years renewable.

Persons interested should send written applications with full particulars about qualifications and previous experience, family situation, date at which free, etc. . . ., to

Electrobel-Traction & Electricite
31, rue de la Science,
Brussels—Belgium,
where applications will be examined and information can be obtained.

Trade Literature

(Continued from page 70A)

Plastics Materials Catalog. A 1958 catalog of plastic materials for industry is now available from Delta Products Division of Air Accessories, Inc., 1400 Henderson, P.O. Box 1440, Fort Worth 1, Texas. The 144-page catalog gives current specifications and prices on most plastics in production today. Sheets, rods, film, tubing, and specialized plastics are covered. Copies are available without cost or obligation.

Transductor Catalog. A 16-page catalog on the electronic industry's first standard line of transductors has been issued by CONTROL, a Division of Magnetics, Inc., Butler, Pa. Catalog *T-10* describes CONTROL's two transductor designs; one open for bus bar use, and one enclosed for cable service. Available in nine sizes, six of the units, four closed and two open, are for 120-volt application, and three (open) for 240-volt use. Capacities range from 200 to 10,000 amperes. Copies of Catalog *T-10*, "CONTROL Standard Transductors," may be obtained by writing to the company.

Silicon Rectifier Handbook. A completely revised edition of their silicon rectifier has recently been issued by The Rectifier Division, Sarkes Tarian, Inc., 415 N. College Ave., Bloomington, Ind. Ask for Number *67*. Although the book bears a $1.00 price, a free copy will be sent to interested *Electrical Engineering* readers.

Lighting Literature. Two booklets and a folder have recently been published by Day-Brite Lighting, Inc. One booklet covers the company's Mobilex and Troffer line of recessed fluorescent lighting. Another covers the Daylume series of surface mounted lighting elements, and the folder presents a new combined light and air diffusing troffer called Paraflo. Copies may be obtained by writing to: Day-Brite Lighting, Inc., Marketing Department, 6260 N. Broadway, St. Louis 15, Mo.

X-ray Analysis Theory. A 12-page booklet titled "X-ray Analysis Theory and Instrumentation" is available gratis from the Instruments Division, Philips Electronics, Inc., 750 S. Fulton Avenue, Mount Vernon, N. Y. Text covers principles of operation and uses simple diagrams to illustrate the basic differences between film diffraction, diffractometry, and spectrography. Illustrated with photos, special sections treat each of the three methods in detail.

Weldirectory. How to select the most efficient electrode for any particular welding job is the subject of a 12-page weldirectory published by The Lincoln Electric Company, 22777 St. Clair Ave., Cleveland 17, Ohio. The back of the Weldirectory is a wall chart containing frequently used information about Lincoln electrodes. The Weldirectory is available free on request.

(Continued on page 75A)

ENGINEERS. (a) Application Engineer, 28-40, graduate electrical, with electrical apparatus experience either in engineering or sales; experience in writing technical letters. Will handle correspondence from sales engineers and customers on inquiries for technical and product information; make occasional product presentations; service equipment in territories not covered by sales engineers. Salary, $7800-$10,000 a year. Occasional travel. (b) Sales Engineers, graduate electrical, to handle the sale of electrical apparatus such as fuse cutouts, lightning arresters, switches, capacitors, etc. Must have proven and successful sales record and some utility experience. Salary, $7800-$12,000 a year depending upon qualifications. Territories: New York, N. Y., Chicago, Illinois, Atlanta, Georgia and Cleveland, Ohio. W6180.

ENGINEER, 30-40, electrical or mechanical graduate, for large insurance organization. Utility power place experience particularly desirable, also some knowledge of nuclear engineering. Background should make applicant adaptable for activities in other engineering fields, leading to position of general engineering consultant. Must be U. S. citizen, and have, or be able to obtain Secret clearance. Salary open; placement fee to be negotiated. Some traveling. Location, New York, N. Y. W6195.

ASSISTANT OR ASSOCIATE PROFESSOR for Department of Electrical Engineering. M.S. degree minimum, with teaching experience desired. Major interests in circuits, computers or servos. Will teach and develop courses for undergraduate and graduate students. Salary open. Location, Midwest. W6196.

ELECTRICAL DESIGN ENGINEERS—RECTIFIERS: with switchgear and transformer experience, for design and development of heavy duty metallic rectifiers, germanium and silicon. Excellent opportunity. Salary open. Location, Southern California. S3553.

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Please write to: Mr. D. G. Stevenson, Engineering Personnel, North American Aviation, Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

Trade Literature

(*Continued from page 72A*)

Consulting Engineer Specification Manual. A 24-page Consulting Engineer Specification Manual, which provides up-to-date, clear, and simplified specifications on electrical distribution equipment, has been published on safety switches, panelboards, switchboards, dimmerboards, control centers, bus duct, and substations. Copies are available upon request from Square D Company, 6060 Rivard St., Detroit 11, Mich.

Dosimetry Booklet. Greater use of radioactive materials, both medically and industrially, has brought about increased awareness of the need for radiation detection and safeguards against exposure of personnel. Dosimetry, a technique of measuring high-energy radiation dosage, makes use of small badge-like packets containing one or more types of film selected to cover a certain range of radiation dosage. A 14-page technical booklet, *A-1009a*, describing seven types of dosimeter films, useful exposure ranges, processing, and calibration, plus a bibliography on dosimeter film usage, is available without charge from the Du Pont Company, Room N-2420-2, Wilmington 98, Del.

Switching Reactor Catalog. A 16-page catalog on the complete line of standard switching reactors for one-step, low cost static control has been issued by Control, a Division of Magnetics, Inc., Butler, Pa. Catalog *S-10* describes the two types of units: one operates from standard line 120 voltages, the other delivers standard load voltages. Available with as many as five control windings, both are offered in 15, 75, 150, and 300 volt-ampere ratings. Copies of Catalog *S-10*, Control standard switching reactors may be obtained by writing to the company.

Silicon Rectifier Data Sheets. The *J* series of silicon rectifiers offer a wide range of ratings. Small size and low cost allow the use of this series in even the most competitive applications. Stud mounting is offered on the *J-2* series and axial leads on the *J-1*. For complete information send for data sheets to Sarkes Tarzian, Inc., Rectifier Division, 415 N. College Ave., Bloomington, Ind.

Aluminum Paints Brochure. A 4-page brochure explaining why aluminum and aluminum graphite paints give high protective service on steel, galvanized iron, tin plate, and other hard-use surfaces has recently been released. In addition to describing a wide variety of aluminum and aluminum graphite paints available, the brochure contains full data on the relative merits of different types of aluminum paints. Also featured are chips which show the actual colors of the different aluminum formulations. Copies of the brochure may be obtained by writing to the Paint Sales Division, the Joseph Dixon Crucible Company, Jersey City 3, N.J. Please be sure to request brochure *V-86*.

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Write today for details on this "engineer's company." We will send you our illustrated brochure "New Dimensions" . . . a tour of Westinghouse-Baltimore and a picturesque introduction to gracious living in Maryland.

Write to: Dr. J. A. Medwin, Dept. 779, Westinghouse Electric Corporation, P. O. Box 746, Baltimore 3, Maryland.

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CLASSIFIED ADVERTISING

For help and situations wanted, $2.00 per line, minimum 5 lines, maximum 30 lines. Sale and purchase of used machinery, etc., $2.50 per line, not available to dealers. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y., unless other address is given.

Positions Open

PROFESSOR OF ELECTRICAL ENGINEERING—to teach and do research in the field of communications. Should have Ph.D., teaching and research experience. $9,400-$12,000. Write Box 468.

ELECTRICAL ENGINEER — Electrical Engineer interested in electrical design of power plants or industrial plants. Experience not required. Excellent opportunity with consulting engineering firm in Middle West. Liberal benefit plans and good working conditions. Send resume of education and experience with statement of salary requirement to: Box 492.

ASSOCIATE OR PROFESSOR OF ELECTRICAL ENGINEERING to teach undergraduate courses in communications and part time research. To twelve thousand for eleven months. Ph.D. degree. Dean of Engineering, University of Santa Clara, Santa Clara, California.

GENERAL ELECTRIC ADVANCED ELECTRONICS CENTER at Cornell University has openings for experienced electronic engineers and physists. As the Advanced Engineering Component of the Light Military Electronic Equipment Department, the Center is responsible for Applied Research and Advanced Development of Airborne Electronic Equipment. Current work at the Center includes Electronic Warfare, Radar, Communications, Data Processing, Weapons Systems Engineering, Proximity Fuses, Magnetic Amplifiers, Human Engineering, Infrared and Transistors. Replies stating education, experience and salary requirements should be addressed to Dr. Paul Doigan, General Electric Company, Advanced Electronics Center at Cornell University, Ithaca, New York. All replies will be kept confidential.

SALES ENGINEER, Electrical, with background of maintenance of rotating electrical machinery. Location, Cleveland area. Opportunity. Salary open. Box 629.

ASSISTANT OR ASSOCIATE PROFESSOR M.S. minimum with interest in circuits, computers or servos. Land Grant School in Midwest. Salary open. Teach undergraduate and graduate courses through M.S. Box 630.

ASSISTANT PROFESSOR OR ASSOCIATE PROFESSOR with advanced training and experience to teach courses in electric power engineering and cooperate in developing a graduate program. Start September 1, 1958 or January 1, 1959. Salary $6000 to $8000 for nine months. Medium-size university engineering college in central Great Lakes region. New Engineering building ready 1959. Box 631.

ELECTRICAL ENGINEER, engineering graduate, 5 to 10 years experience in design, construction and maintenance of distribution system of public utility in South Alabama. Salary commensurate with experience and education. Communications confidential. Box 632.

ASSOCIATE PROFESSOR for Electrical Engineering Department. Ph.D. degree preferred. Opening in electronics. Salary commensurate with experience and education. Position available September 1958. Write Head, Electrical Engineering Department, South Dakota School of Mines and Technology, Rapid City, South Dakota. Box 633.

CHIEF ELECTRICAL ENGINEER, with at least 8 years experience in designing AC and DC motors and generators in integral horsepower sizes, to head section to design and develop large variety of military and commercial machines. Salary commensurate with background; sound fringe benefit and retirement program. Send resume of education and experience to William Pentin, Chief Engineer, Safety Industries, Inc., P.O. Box 904, New Haven 4, Connecticut.

WANTED MECHANICAL ENGINEER, for assistant superintendent of service engineering in large manufacturing plant, Southern location. Should have degree in mechanical engineering. Prefer man with experience in operation and maintenance of steam and power generating equipment. Knowledge of electrical maintenance and construction would also be helpful. Box 634.

Positions Wanted

ELECTRICAL ENGINEER. Graduate Mechanical. Turkish citizen, 30, family and 2 children. Can speak English and French. 6 years experience in lighting, power distribution of cold storage plants, including diesel-generator power plants. Knowledge about semiconductors. Last 3 years chief electrical engineer of a big firm. Can start in 30 days. Locate anywhere, overseas acceptable. For complete brochure write to Box 635.

ELECTRICAL DESIGN, Specification and Sales Engineering Position Wanted—Location Open—Prefer Midwest or West—Age 45—Physical Condition Excellent—Over 20 Years Successful Experience Electrical Engineering, Design, Specification, Consultant on Hospitals and Industrials—Limited Mechanical Specification and Design Experience — Considerable Experience during same period of time, all of which has been with same company, Sales Management. Member AIEE: ASRE: IES—Prefer position where engineering, design and specification talents can be utilized with sales experience. Box 636.

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